Productivity in Scientific Teams:

The Effects of Transformational Leadership, Person–Environment Fit, and Teamwork Quality on Performance and Well-Being in Scientific Teams

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Abstract

Team-based work structures have become prevalent in scientific work. However, situations strongly characterized by mixed motives such as conflicting individual- and team-level aims make leading scientific teams especially demanding. Moreover, scientific team members suffer from high occupational stress due to disadvantageous work characteristics, such as contingent employment, in higher education institutions[1]. This makes scientific teams a unique and particularly challenging team setting. However, studies investigating team leadership and group dynamics in scientific teams are rare. So far, only one study has investigated the effects of transformational leadership and trust on performance and well-being in scientific teams in higher education institutions (Braun, Peus, Weisweiler, & Frey, 2013). Thus, this thesis draws on the dual-focused model of transformational leadership, person–environment fit theory, and the teamwork quality model to extend the current research field on team leadership and teamwork by presenting two studies about the effects of transformational leadership, person–environment fit, and teamwork quality on productivity in scientific teams. These studies make a strong contribution to the research field by increasing knowledge of the psychological processes that explain the effects of leadership on scientific productivity. The findings of these studies can be practically applied by leaders of scientific teams and human resource managers in higher education institutions to improve productivity in the scientific work context.

[1] In this thesis, I use the terms higher education institutions and universities interchangeably.

Summary

Part I provides an overview of the specifics of the scientific work context and the challenges of scientific teams in higher education institutions. I present the aim of my dissertation thesis and the theoretical concepts I used to explain which factors improve performance and well-being in scientific teams.

Part II is divided into Chapter 1 and Chapter 2, which present the two studies I conducted to extend the current research field on team leadership and teamwork in science. The research findings in Chapter 1 have been published in the *European Journal of Work and Organizational Psychology*, while the findings in Chapter 2 have been submitted to *Group & Organization Management*.

Chapter 1 introduces a time-lagged study with 42 scientific teams on whether person–supervisor fit, needs–supplies fit, and team fit mediate the relationship between dual-focused transformational leadership and well-being in scientific teams. Overall, the results largely support the hypotheses. The relationships between individual-focused transformational leadership, job satisfaction, and work-related strain were mediated by needs–supplies fit and person–supervisor fit. Additionally, group-focused transformational leadership was positively related to job satisfaction and negatively related to work-related strain. However, team fit was not the explanatory mechanism behind the group-focused transformational leadership and well-being relationship.

Chapter 2 extends the findings of the first study by explicitly investigating team-level process factors for the link between transformational leadership and work-related outcomes. A time-lagged design with 79 scientific teams was used to test whether teamwork quality mediated the relationship between group-focused transformational leadership and team innovation and learning in scientific teams. Again, the results largely support the hypotheses. The relationship between group-focused transformational leadership and learning was mediated by teamwork quality. Group-focused transformational leadership was positively related to team innovation as well, but teamwork quality did not mediate this relationship.

Part III concludes with an overview of the core findings and the contribution of my research to the greater research field. I also discuss the strengths and limitations of the research I conducted and present implications for research and practice.

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Contents

Part I: Overview

Part I provides an overview of the specifics of the scientific work context and the challenges facing scientific teams in higher education institutions. Further, it presents the aim of this dissertation thesis and the theoretical concepts used to explain which factors improve performance and well-being in scientific teams.

Introduction

Recent decades have seen a shift from individual to team-based work structures in most organizations to enhance efficiency and productivity (Hollenbeck, Beersma, & Schouten, 2012; Kozlowski & Ilgen, 2006; Mathieu, Hollenbeck, van Knippenberg, & Ilgen, 2017). Team-based work structures have become prevalent in the context of scientific work at higher education institutions as well (Cooke & Hilton, 2015; Vabø, Alvsvåg, Kyvik, & Reymert, 2016). As a result, a vast number of studies have investigated the effects of teamwork on employee productivity (e.g., job performance and well-being). However, these studies use samples of employees from work contexts such as sales, marketing, and finances. Although the scientific work context has some similarities with these other work contexts, scientific teams differ from other teamwork settings in several salient characteristics, such as contingent employment, conflicting role requirements, strong mixed-motive situations, and limited promotion prospects (Feldman & Turnley, 2004; Goastellec, Park, Ates, & Toffel, 2013; van der Weijden, Teelken, Boer, & Drost, 2016). These characteristics make the scientific work context particularly challenging, as team members suffer from high occupational stress due to these demanding work characteristics (Bozeman & Gaughan, 2011; Levecque, Anseel, de Beuckelaer, van der Heyden, & Gisle, 2017; Reevy & Deason, 2014). For example, the occurrence of mental health issues such as anxiety and depression is twice as high in samples of PhD students as in highly educated employees in other work contexts (Levecque et al., 2017).

Initial studies on scientific productivity focused on work outcomes such as publication output of senior scientists such as full professors. However, as team-based work structures have become prevalent in higher education institutions across all scientific disciplines (Cooke & Hilton, 2015; Vabø et al., 2016), research should consider the team-level factors that might influence scientific productivity. These include the work outcomes of not only senior scientists but also junior scientists (e.g., PhD students and postdoctoral researchers). Thus, the aim of this thesis is to close these fundamental research gaps on leadership and teamwork in the scientific work context. For the present thesis, I investigated which factors affect productivity in scientific teams. I conducted two studies on scientific teams, in which I investigated factors such as transformational leadership, the match between personal and workplace characteristics, and the quality of teamwork; these are all key to enhancing productivity in scientific teams. The work characteristics are difficult to change in higher education institutions, because they usually require alterations at the organizational-level. Against this background, I investigated factors at the team- and individual-levels that may be changed more readily and more easily. Leaders of scientific teams need to reflect on their leadership behaviours and consider adopting transformational leadership behaviours to enhance team members' perceptions of fit at work (e.g., team member having similar attitudes and values regarding work ethics), the quality of teamwork, and ultimately productivity in scientific teams.

To date, a few narrative, rather dated literature reviews exist on scientific productivity (Bland & Ruffin, 1992; Fox, 1983; Johnsrud, 2002; Zainab, 1999, 2000). In her literature reviews, Zainab summarized the personal, academic and departmental/institutional correlates of individual publication performance. A range of *personality traits* have been positively related to publication performance, including strong achievement motivation, cognitive styles (e.g., tolerating ambiguity and abstraction), high levels of intrinsic motivation, intense devotion to work, strong absorption in work (e.g., flow), high levels of job identification, persistence, creativity, and self-confidence. *Academic* correlates that are positively related to publication performance include qualifications and experiences (e.g., acquaintance with various research practices). *Departmental/institutional* correlates are: reinforcement/reward/recognition, employment in a prestigious institution, sufficient time for research and teaching, work variety, department size, effective management practices, supervision of graduate students, financial support (e.g., funds for travelling expenses), library support (e.g., access to databases), and electronic support.

Beside these narrative reviews, several more recent studies have examined determinants of scientific productivity such as publication performance and well-being. *Individual characteristics* related to enhanced scientific productivity include successful time management, extrinsic motivation (e.g., promotion prospects), research self-efficacy, conscientiousness, and job involvement (Buchheit, Collins, & Collins, 2001; Chen, Gupta, & Hoshower, 2006; Hardré, Beesley, Miller, & Pace, 2011; Q. Hu & Gill, 2000; Jerneić & Kutleša, 2012; Pasupathy & Siwatu, 2014; Perry, Clifton, Menec, Struthers, & Menges, 2000; Tien, 2000; White, James, Burke, & Allen, 2012). *Team characteristics* linked to improved scientific productivity are team size, support from colleagues, a positive team climate, and team commitment (Cummings, Kiesler, Bosagh Zadeh, & Balakrishnan, 2013; Neumann & Finaly-Neumann, 1990; Louis, Holdsworth, Anderson, & Campbell, 2007). *Organizational characteristics* related to higher scientific productivity include support for research (e.g. grants), fewer teaching obligations, and a creative work climate (Buchheit et al., 2001; Chen et al., 2006; Fox & Mohapatra, 2007; Hardré et al., 2011; Q. Hu & Gill, 2000; White et al., 2012).

In summary, a large body of literature exists on the topic of scientific productivity. Individual, team, and organizational characteristics have all been examined as determinants of scientific productivity. But these studies are not without limitations. The critics stress the restricted samples (mostly professors), the cross-sectional research designs, and the need for more multivariate, multilevel models and analyses (Braun et al., 2013). Remarkably little systematic research exists on the topic of productivity in *scientific teams*. Previous studies on scientific productivity have examined the relationships between particular predictors (e.g., team cohesion) and productivity in samples of research and development teams in non-university settings (Chun, Cho, & Sosik, 2016; Dong, Bartol, Zhang, & Li, 2017; Hoegl & Gemuenden, 2001; Y. Jiang & Chen, 2018; W. Jiang, Gu, & Wang, 2015; Kristof-Brown, Seong, Degeest, Park, & Hong, 2014; Li, Mitchell, & Boyle, 2016; Wang & Howell, 2010, 2012) or in undergraduate student teams (Watson, BarNir, & Pavur, 2005; Watson, Johnson, & Zgourides, 2002). The samples from the studies mentioned in this literature review are limited to full, associate, and assistant professors. Therefore, the majority of studies on scientific productivity in higher education institutions have examined productivity in single individuals and less in scientific teams. So far, only one study has investigated the effects of transformational leadership on trust, team research performance, and job satisfaction in a sample of scientific teams (Braun et al., 2013). My dissertation thesis takes this study as its starting point and continues to investigate additional factors influencing productivity in scientific teams.

In the sections following this introduction, I first provide an overview of the characteristics of the scientific work context and – in line with the aims of the present thesis – highlight the relevance for studying productivity in scientific teams. Next, I provide an overview of the factors affecting work outcomes in scientific teams and the theories addressing these: the dual-focused model of transformational leadership (Wang & Howell, 2010), person–environment fit theory (Kristof-Brown, Zimmerman, & Johnson, 2005), and the model of teamwork quality (Hoegl & Gemuenden, 2001). The two chapters (Chapters 1 and 2) of the second part contain the published paper and submitted manuscript of the studies conducted on scientific teams. Finally, I conclude in the third part with a general discussion and a summary of the major findings of my research, a discussion of its strengths and limitations, and suggestions regarding its implications.

Work Context: Scientific Teams

Nowadays, team-based work structures have become prevalent across all scientific disciplines (Cooke & Hilton, 2015; Vabø et al., 2016). For instance, co-authoring in scientific publications has increased (Pflüger, 2013). Moreover, co-authoring tends to increase the chances of acceptance. Gordon (1980) found a significant positive correlation between the number of authors of papers submitted to a leading astronomy journal and their frequency of acceptance for publication: Of the 1859 papers examined, 63% of the single-author papers, 77% of the two-author papers (78%), and 82% of the three-author papers had been accepted. Moreover, Gordon (1980) received information on rejection rates for this specific journal and found that 26% of the single-author papers were rejected, indicating a rejection rate twice as high for single-author papers as for to two-author papers (12%) and three-author papers (10%). Furthermore, Fox and Mohapatra (2007) state that "coauthored work, in turn, fares better in the publication process than solo-authored work." (p. 545). This can be explained by the team composition: the team benefits from the diversity in knowledge, skills, and abilities (KSAs) of their individual teammates, because the broad array of KSAs provides support in the difficult task of idea generation and implementation (Hülsheger, Anderson, & Salgado, 2009). Katz and Martin (1997) point out that "modern research is increasingly complex and demands an ever-widening range of skills. Often, no single individual will possess all the knowledge, skills and techniques required." (p. 14). Thus, scientific teams may benefit from the sharing of KSAs, the transfer of knowledge and skills, new perspectives and ideas, the wider network of contacts in the scientific community, and therefore the enhanced potential visibility of scientific work (Katz & Martin, 1997). As a result, scientists increasingly collaborate with other scientists from the same discipline or from other disciplines to promote research excellence.

The increase in teamwork raises the question of efficient leadership (Braun, Peus, Frey, & Knipfer, 2016; Peus, Braun, & Schyns, 2016). Scientific teams need a team leader (e.g., principal investigator), who directs the strategic alignment of the team's performance and supports the team's plans and projects through the provision of resources. Consequently, leaders of scientific teams are confronted with the issues of building and leading a team. Leading scientific teams is a challenge for team leaders in higher education institutions. Lowman (2010) argues that "leadership in the corporate arena, however complex that might be, is substantially less complex than leading in academia" (p. 241). This is due to the challenging work characteristics of science: Scientific team members usually may only be employed part time and fixed term, and the promotion prospects are very uncertain. Both team leaders and team members have to deal with conflicting role requirements, as work in academia requires research, teaching, and service activities. Furthermore, strong mixed-motive situations pose a threat to effective team leadership and teamwork, as individual-level needs and goals are often in conflict with team-level needs and goals (e.g., discussions about authorship in publications). Lastly, budget cuts and increased competition for research resources impose an even greater burden on leaders and members of scientific teams (Feldman & Turnley, 2004; Goastellec et al., 2013; Levecque et al., 2017; Reevy & Deason, 2014; van der Weijden et al., 2016). Team leaders in higher education institutions are professors or principal investigators, who often lack formal leadership training. They have been appointed to their position on the basis of their research performance and expertise. However, they assemble a team of junior researchers to provide support for research, teaching, and administrative tasks. Besides this, leaders in higher education institutions need to lead team members to accomplish goals successfully. As team members increasingly accomplish their work tasks within team-based work structures, team-level processes need to be considered as determinants of work motivation and engagement by leaders of scientific teams if they are to create and maintain a high-quality research environment (Cooke & Hilton, 2015; Vabø et al., 2016).

Since several factors such as leadership and team-level processes may affect productivity in scientific teams, work outcome measures need to be investigated to assess the effects of these factors on productivity. Scientific productivity may not be treated as equivalent to the general definition of the term productivity, as it is difficult to measure the ratio of labour input (i.e., amount of work) to labour output (i.e., production result) in the case of scientific teams in higher education institutions. However, this also applies to a variety of other non-scientific work contexts, where it is almost impossible to assess labour input and output objectively and reliably (e.g., education, healthcare). Thus, it is often a challenge to find appropriate indicators for productivity. In social and work psychology, researchers investigate such indicators of productivity as job performance (e.g., research performance, innovation), job attitudes (e.g., turnover intention), and well-being (e.g., job satisfaction, work-related strain; Sonnentag & Frese, 2003). Productivity is not only defined as an output-to-input ratio but also by whether the working process per se is considered productive (e.g., "Today, I worked very efficiently"). For example, Braun et al. (2013) investigated job satisfaction and team research performance (i.e., number of peer-reviewed publications weighted by journal impact factor) in their study on the productivity in scientific teams. According to Braun et al. (2013), it is important not to only investigate indicators for productivity such as job performance, but also to investigate well-being, because well-being, measured by perceived job satisfaction and work-related strain, influences the motivation of scientific employees and thus determines work effort and job performance in the long run. This becomes all the more important because low levels of employee well-being are a major problem in science (Levecque et al., 2017; Reevy & Deason, 2014). In line with this research, I also investigated work-related outcomes such as job performance (i.e., team innovation and learning) and well-being (i.e., job satisfaction and work-related strain).

In both studies, I also tried to assess team research performance via objective data (e.g., indicators such as number of peer-reviewed publications weighted by source-normalized impact per paper) as another indicator of job performance. Measuring team research performance has proven to be a challenging task, and no consensus exists on how to measure team research performance accurately (Popova, Romanov, Drozdov, & Gerashchenko, 2017). Nonetheless, I made a considerable effort to collect indicators of team research performance from Web of Science and Scopus (i.e., number of publications, journal impact factors, source normalized impact per paper, percentile in subject area). To account for differences in the publication process between disciplines (e.g., length of papers, number of authors, citation speed), I combined some of the indicators to achieve a fair comparison of team research performance between the scientific teams in the samples. For example, the number of publications, published between 2016 and first half of 2017, was weighted by source-normalized impact per paper (SNIP). I decided to use SNIP as the weighting factor instead of journal impact factor, because the SNIP takes into account the differences in publication process between the disciplines. Only publications with at least two team members as authors were included for the average scoring of team research performance.

However, I encountered a major problem during data gathering, as I had many missing values in my dataset; some teams had not published anything at all or only a limited number of publications (e.g., less than two publications). This is not surprising, because the process from project start to project end and the subsequent publication process take two to five years. However, I gathered the data on team research performance some 12 to 18 months after data collection with questionnaires. This time frame may have been too short to gather sufficient data on research performance for all the scientific teams investigated in my studies. Similarly, in Braun et al.'s (2013) study, the analyses using team research performance as the outcome variable had to be performed with a reduced sub-sample ($N = 28$), because the values for team research performance were missing for some teams ($N = 11$). In a study by Peltokorpi and Hasu (2014), team innovation performance was operationalized by collecting objective data on the number of patent applications. Peltokorpi and Hasu (2014) had missing data for 87% of the research and development teams investigated in their study (N_{total} = 124). Finding appropriate measures for productivity in scientific teams is a complex and challenging endeavour, especially when collecting objective team performance data. Thus, in consultation with my co-authors, I have chosen not to include team research performance as a work-related outcome variable in the papers.

Transformational Leadership

Transformational leadership is the most researched leadership concept to date and has been found to positively affect the work-related outcomes of employees in various work contexts (Banks, McCauley, Gardner, & Guler, 2016; Hoch, Bommer, Dulebohn, & Wu, 2018). In general, transformational leadership has a positive effect on motivation at work, job performance, work behaviour, attitudes towards the work situation, and the well-being of employees. Additionally, newer types of leadership behaviour, such as authentic leadership and ethical leadership, do not contribute much beyond transformational leadership to explaining incremental variance in work-related outcomes. Thus, transformational leadership is a prominent leadership concept and is receiving increasing attention in the research field of industrial/organizational and social psychology, despite severe criticism by van Knippenberg and Sitkin (2013). The full range leadership model by Avolio and Bass (1991) and the dual-focused model of transformational leadership by Wang and Howell (2010) are prominent theoretical frameworks for explaining the effects of transformational leadership on work outcomes in organizations.

The full range leadership model encompasses three leadership styles: (1) Laissez-faire, (2a) transactional leadership – management by exception, (2b) transactional leadership – contingent reward, and (3) transformational leadership. *Laissez-faire leadership* is characterised by a supervisor who avoids making decisions, abdicates responsibilities, refuses to take sides in disputes, and shows a lack of interest. Consequently, laissez-faire leadership is seen as non-management. *Transactional leadership* comprises a factual exchange process between a supervisor and his/her subordinates, which means that the supervisor rewards his/her subordinates for the fulfilment of their work duties (i.e. contingent reward). The supervisor is primarily focused on maintaining the status quo, on error-tracking and troubleshooting (i.e. management-by-exception). Supervisors showing *transformational leadership* behaviours develop and stimulate their subordinates intellectually by encouraging followers to revisit problems in a creative manner (i.e., intellectual stimulation). Therefore, transformational leadership goes beyond transactional leadership by acknowledging non-material needs such as self-fulfilment in addition to material needs (i.e., individualized consideration) and by inspiring its followers through an optimistic view of the future (i.e., inspirational motivation). Supervisors with a transformational leadership style are seen as role models because they are characterized by expertise and charismatic behaviour (i.e., idealized influence).

Of these three leadership styles, only transformational leadership and contingent reward as a subcomponent of transactional leadership were examined in my doctoral studies, as they represent effective leadership behaviours (Judge & Piccolo, 2004). A meta-analysis by Judge and Piccolo (2004) found contingent reward to be positively related to job satisfaction ($\rho = .64$), satisfaction with the supervisor ($\rho = .55$), motivation of employees ($\rho = .59$), team performance ($\rho = .16$), and the perceived effectiveness of the supervisor ($\rho = .55$). Furthermore, Judge and Piccolo (2004) reported positive correlations between transformational leadership and employees' job satisfaction ($\rho = .58$), satisfaction with the supervisor ($\rho = .71$), motivation of employees ($\rho = .53$), and team performance ($\rho = .26$). Braun et al. (2013) found transformational leadership to be positively related to individual followers' job satisfaction and team publication performance. The dual-focused model of transformational leadership also focuses only on transformational leadership and contingent reward. Wang and Howell (2010) define contingent reward in their dual-focused model of transformational leadership as a subcomponent of individual-focused transformational leadership and rename it personal recognition. However, the dual-focused model of transformational leadership is an extension of the full range leadership model, as, in contrast to the full range leadership model, it differentiates between leadership behaviours directed towards individual employees (i.e., individual-focused transformational leadership) and leadership behaviours directed towards a team as a whole (i.e., group-focused transformational leadership). As team-based work structures have become prevalent in science, it is necessary to look at leading not only individuals but also teams.

In the dual-focused model of transformational leadership, individual-focused transformational leadership differs from group-focused transformational leadership. *Individual-focused transformational leadership* refers to leadership behaviours that aim to encourage employees to set high goals for themselves (i.e., communicating high expectations), suggest training opportunities for improving employees' work-related abilities (i.e., follower development), challenge employees to think about old problems in new ways (i.e., intellectual stimulation), and acknowledge employees for improving the quality of their work (i.e., personal recognition). Conversely, *group-focused transformational leadership* refers to leadership behaviours that aim to encourage team members to place the interests of the team ahead of their own interests (i.e., emphasizing group identity), communicate a clear direction of where the team is going (i.e., communicating a group vision), and resolve frictions among team members in the interest of teamwork (i.e., team-building). Individual-focused transformational leadership has been related to identification with the leader, individual performance (Wang & Howell, 2012), and individual skill development (Dong et al., 2017); group-focused transformational leadership has been related to identification with the group, group performance (Wang & Howell, 2012), team knowledge sharing, and team creativity (Dong et al., 2017).

However, only a few studies have investigated transformational leadership as a factor influencing productivity in scientific teams in higher education institutions (Braun et al., 2013; Braun et al., 2016; Peus et al., 2016). As already mentioned, leading scientific teams in higher education institutions is particularly challenging due to the demanding work characteristics, which put both team leaders and team members under substantial pressure (Lowman, 2010; Peus et al., 2016). Transformational leadership seems to be a promising approach for team leadership in higher education institutions (Braun et al., 2013; Braun et al., 2016; Peus et al., 2016). However, more studies are needed on the effects of team-centric types of leadership (e.g., group-focused transformational leadership) on work-related outcomes in scientific teams (Braun et al., 2016; Peus et al., 2016). To address this gap, I investigated the effects of transformational leadership on productivity in scientific teams by referring to the prominent full range leadership model by Avolio and Bass (1991) and the more recently developed dual-focused model of transformational leadership by Wang and Howell (2010).

Person–Environment Fit

Person–environment (PE) fit theory (Kristof-Brown et al., 2005) has gained popularity as a central stress theory in the research stream of work and organizational psychology. Person–environment fit is defined as a congruence between the characteristics (e.g., values) of an individual and the environment (Kristof-Brown et al., 2005). The person–environment fit construct is composed of five dimensions: person–vocation (PV) fit, person–organization (PO) fit, person–group (PG) fit, person–individual (PI) fit and person–job (PJ) fit, of which the latter is divided into needs–supplies (NS) fit and demands–abilities (DA) fit.

Person–vocation fit is defined as the compatibility between an employee and his/her vocations/professions (Hansen & Lee, 2007). For example, an employee perceiving person–vocation fit to be high would agree with the statement that his/her current profession offers him/her everything he/she seeks from a profession. If person–vocation fit is low, an employee would indicate that his/her profession requires him/her to be someone he/she is not.

Person–organization fit is defined as a value congruence between an employee and the organization he/she is currently employed at. For example, if person–organization fit is high, an employee would concur with the statement his/her organization's values and culture provide a good fit with the things that he/she values in life. If an employee perceives person–organization fit to be low, he/she would indicate that his/her personal values do not match his/her organization's values.

Person–group fit is defined as a compatibility between co-workers in terms of having similar values and attitudes. For example, an employee perceiving person–group fit to be high would agree with the statement that his/her values and attitudes are compatible with the values and attitudes of his/her co-workers. If person–group fit is low, an employee would indicate that his/her goals do not match the group's goals.

Person–individual fit is defined as a congruence between an employee and another individual in the same organization regarding values and attitudes. Person–supervisor fit, a type of person–individual fit, is defined as attitudinal compatibility between a supervisor and his/her subordinate. For example, if person–supervisor fit is high, an employee would concur with the statement that the things he/she values in life match the things his/her supervisor values in life. If an employee perceives person–supervisor fit to be low, he/she would indicate that his/her work style do not match his/her supervisor's work style.

Person–job fit is defined as a compatibility between what an employee contributes to the job and what the current job offers an employee. Needs–supplies fit, one type of person–job fit, is defined as a correspondence between an employee's needs (e.g., more autonomy at work) and what the job supplies (e.g., employees have a high degree of discretion to perform their work). Demands–abilities fit, another type of person–job fit, is defined as a compatibility between an employee's knowledge, skills, and abilities and the demands and requirements of the job.

The basic assumption of the person–environment fit theory is that the degree of congruence or fit between person and environment is related to the extent of positive and negative consequences (Kristof-Brown et al., 2005). Thus, a high person–environment fit is perceived as a resource that leads to positive outcomes, whereas a low person environment fit is perceived as a stressor that influences work-related outcomes negatively (Edwards, 1996). These assumptions have been confirmed in numerous studies and in a meta-analysis by Kristof-Brown et al. (2005): Person–organization fit is positively related to job satisfaction ($\rho = .44$) and negatively related to work-related strain ($\rho = -.44$). Further, the higher the person–group fit, the higher are job satisfaction ($\rho = .31$) and satisfaction with co-workers ($\rho = .42$). Person–supervisor fit is positively related to job satisfaction ($\rho = .44$) and supervisor satisfaction ($\rho = .46$). Lastly, the higher the person–job fit, the higher is job satisfaction ($\rho = .56$) and the lower is work-related strain ($\rho = -.28$). A recent meta-analysis by Oh et al. (2014) demonstrates that the fit dimensions are positively related to work-related outcomes such as job satisfaction and job performance even across cultures (i.e., East Asia, Europe, North America), which demonstrates the universal relevance of a close match between personal and workplace characteristics.

Person–environment fit theory contributes to the research on productivity in scientific teams, as the scientific work environment is characterised by work–related stressors such as high workload (Hardré et al., 2011; Levecque et al., 2017; Neumann & Finaly-Neumann, 1990; Reevy & Deason, 2014; White et al., 2012). A close match between personal und environmental characteristics could therefore be perceived as a resource that increases motivation and persistence in this highly competitive and demanding environment. Conversely, a low person–environment fit could be perceived as another stressor, which could lead to a deterioration in work motivation, attitudes (e.g., job satisfaction), and behaviour (e.g., turnover). Thus, I investigated the dimensions of person–environment fit theory as mediating variables for the relationship between transformational leadership and work-related outcomes.

Teamwork Quality

Teamwork quality is a theoretical concept developed by Hoegl and Gemuenden (2001) that defines what constitutes high quality in interactions within teams and how teamwork quality affects personal success (e.g., job satisfaction, learning) and team performance. Teamwork quality is based on the assumption that team success depends both on the correct execution of tasks and on the quality of teamwork, because teams need both task and social behaviours to function effectively (Hertel & Hüffmeier, 2011; Levi, 2017).

Hoegl and Gemuenden (2001) identified six dimensions of teamwork quality: communication, coordination, balance of member contributions, mutual support, effort, and cohesion. High *communication* quality in teams can be achieved when sufficient time is spent communicating (frequency) and when informal communication (e.g., spontaneously initiated contacts) prevails over formal communication (e.g., scheduled meetings). Furthermore, high communication quality is achieved when team members are able to communicate directly with all other team members (structure) and when team members share their information openly with each other. High *coordination* quality is achieved when teams develop a common task-related goal structure with clear subgoals/activities for each team member. The *balance of member contributions* is optimal when every team member is able to contribute his/her task-relevant knowledge and experience to the team. *Mutual support* requires that team members hold a cooperative frame of mind instead of a competitive one, so that team members support each other. High *effort* is achieved when team members have a common understanding of work norms. And *cohesion* requires that team members retain a sufficient level of desire to remain in the team and engage in collaborative work.

A study by Lindsjørn, Sjøberg, Dingsøyr, Bergersen, and Dybå (2016) found teamwork quality to be positively related to team performance and team members' success (i.e., job satisfaction, learning) in a sample of software development teams. A study by Cha, Kim, Lee, and Bachrach (2015) showed teamwork quality to be the mechanism explaining the positive relationship between transformational leadership and inter-team collaboration within an organization in a sample of research and development teams. Another study on software teams found teamwork quality to be positively related to team performance (e.g., teams' adherence to schedule and budget) and personal success (e.g., learning success; Hoegl & Gemuenden, 2001).

I assume teamwork quality to contribute to the research on work outcomes in scientific teams, as team-based work structures are becoming increasingly widespread in science. Therefore, team characteristics and dynamics need to be considered as factors influencing work outcomes in scientific teams. Scientific teamwork requires exchange of knowledge, skills, and abilities (KSA) between the members of a team (Lee, Walsh, & Wang, 2014; Liu, Keller, & Shih, 2011; Wuchty, Jones, & Uzzi, 2007) and thus – in particular – effective communication (Hirst & Mann, 2004), balance of member contributions, and mutual support (Hoegl

& Gemuenden, 2001). Thus, teamwork quality may be especially relevant for scientific teams' performance and well-being.

Chapter Overview

Two studies, reported here in two chapters, were conducted for the present thesis. Chapter 1 is mainly concerned with explaining the effects of individual-focused transformational leadership and group-focused transformational leadership on team members' well-being by investigating person–supervisor fit, needs–supplies fit, and person–group fit as the mechanisms explaining the relationship between transformational leadership and well-being. Chapter 2 is mainly concerned with explaining the team-level effects of group-focused transformational leadership on team innovation performance and individual team members' learning by investigating teamwork quality as the underlying mechanism for the leadership-outcomes relationships. Thus, these studies provide some insight into whether and how several factors, such as transformational leadership, the match between personal and workplace characteristics, and the quality of teamwork, affect work-related outcomes in scientific teams.

Chapter 1

The aim of Chapter 1 is to establish the relationship between transformational leadership and team members' well-being (i.e., job satisfaction and work-related strain) through three mediators: person–supervisor fit, needs–supplies fit, and person–group fit (i.e., team fit). In line with the dual-focused model of transformational leadership (Wang & Howell, 2010) and person–environment fit theory (Kristof-Brown et al., 2005), I propose that the positive relationship between individual-focused transformational leadership and job satisfaction and the negative relationship between individual-focused transformational leadership and work-related strain are mediated by person–supervisor fit and needs–supplies fit. Further, I propose that the positive relationship between group-focused transformational leadership and job satisfaction and the negative relationship between group-focused transformational leadership and work-related strain are mediated by team fit. Thus, I investigated a multilevel model of transformational leadership by investigating transformational leadership and the match between personal and workplace characteristics at multiple levels simultaneously (i.e., individual and team).

I decided to investigate job satisfaction and work-related strain as indicators of team members' well-being as outcome variables, because the scientific work context is a challenging work environment due to contingent employment, strong mixed-motive situations, and increased competition for research resources (Feldman & Turnley, 2004; Goastellec et al., 2013; Levecque et al., 2017; Reevy & Deason, 2014). In addition, scientific team members suffer from high occupational stress (Bozeman & Gaughan, 2011; Levecque et al., 2017; Reevy & Deason, 2014). Therefore, it is important to focus not only on hard outcomes such as publication performance but also on soft outcomes such as well-being. Job satisfaction is defined as a general appraisal of an employee's current employment situation (Bowling & Hammond, 2008). Job satisfaction is affected by a variety of job characteristics such as salary, the degree of autonomy, job security, competence of colleagues, leadership, and prospects for career advancements, to name a few. In the first study, team members were very satisfied with the degree of autonomy, competence of colleagues, and flexibility in relation to family matters; they were less satisfied with leadership, availability of child care, and prospects for career advancements. Work-related strain is defined as the amount of exhaustion an employee perceives due to high job demands and work stressors (Revicki, May, & Whitley, 1991). For example, employees may indicate that they have difficulties disengaging from the job at home due to high preoccupation with work.

The hypotheses were tested with a sample of 134 team members in 42 scientific teams at two large research universities in Switzerland using a three-wave lagged design: Transformational leadership was assessed six weeks prior to person–environment fit and 12 weeks prior to team members' well-being. Overall, the results largely supported the hypotheses: The relationship between individual-focused transformational leadership and team members' well-being was mediated by person–supervisor fit and needs–supplies fit. Additionally, group-focused transformational leadership was positively related to job satisfaction and negatively related to work-related strain. However, team fit was not the mechanism explaining the group-focused transformational leadership and well-being relationship. This first study is one of the few to have investigated important success factors for team members' well-being in the scientific work context by combining a prominent leadership model with a central stress theory from industrial/organizational and social psychology. Thus, this first study makes a strong contribution to the research field.

Chapter 2

The aim of Chapter 2 is to establish the relationship between transformational leadership and team innovation and individual team members' learning through the mediator of teamwork quality. Since team fit as a team-level factor did not significantly mediate the relationship between group-focused transformational leadership and team members' well-being in Study 1, I tried to find a more suitable team-level factor as a mechanism that explained the leadership-outcomes relationship. Thus, the second study extends the previous research on the factors that positively influence work-related outcomes in scientific teams by investigating factors at the team-level. In line with the dual-focused model of transformational leadership (Wang & Howell, 2010) and the teamwork quality model (Hoegl & Gemuenden, 2001), I propose that the positive relationships between group-focused transformational leadership and team innovation and individual team members' learning are mediated by teamwork quality. So far, studies have investigated single team-level factors, such as team knowledge sharing (Dong et al., 2017) or psychological safety (J. Hu, Erdogan, Jiang, Bauer, & Liu, 2018) as the mechanism mediating the leadership-outcomes relationship. However, effective teamwork depends on more than solely a high degree of knowledge sharing or psychological safety. Multiple factors simultaneously contribute to high-quality teamwork (Hoegl & Gemuenden, 2001). Teamwork quality as a construct is composed of diverse team-level factors, including communication, balance of member contributions, cohesion, mutual support, effort, and coordination. Thus, in the second study, I used a multilevel model of transformational leadership, teamwork quality, team innovation, and individual team members' learning to investigate team-level factors.

In this second study, I decided to investigate team innovation and individual team members' learning as outcome variables because in knowledge-intensive work contexts such as science, it is crucial that team members show a high degree of innovation and learning (Cooke & Hilton, 2015; Vabø et al., 2016). Research and development organizations rely increasingly on employees' innovation performance to cope effectively with pressure and competition (Anderson, Potočnik, & Zhou, 2014; van Knippenberg, 2017; Zhou & Hoever, 2014). Team innovation is defined as an outcome of creative processes (i.e., idea generation) and innovative processes (i.e., idea implementation). Researchers have argued for the differentiation between (a) creativity processes and team creativity performance and (b) innovation processes and team innovation performance. However, in line with recent literature (Anderson et al., 2014), I use the terms team creativity and team innovation interchangeably. Another important outcome for teams in knowledge-intensive work contexts is learning as learning increases knowledge, skills, and abilities, which can enhance success in future projects, and team members' motivation to participate in future team projects (Hoegl & Gemuenden, 2001; Yoon & Kayes, 2016). Individual team members' learning is defined as an individual outcome, which is a result of team members' benefitting from each other's know-how and expertise through working jointly on team projects (Hoegl & Gemuenden, 2001).

The hypotheses were tested with a sample of 235 team members and 64 team leaders of 79 scientific teams at several research universities in Switzerland and Germany using a temporally lagged design with two measurement time points: Transformational leadership was assessed four weeks prior to teamwork quality, team innovation, and individual team members' learning. Overall, the results supported the hypotheses: The relationship between group-focused transformational leadership and individual team members' learning was mediated by teamwork quality. Additionally, group-focused transformational leadership was positively related to team innovation. However, teamwork quality was not the mechanism explaining the relationship between group-focused transformational leadership and team innovation. Nonetheless, supplementary post-hoc analyses revealed that only two dimensions of teamwork quality proved to be significant mediators for the group-focused transformational leadership and team innovation relationship: Cohesion was significantly negatively related to team innovation, while balance of member contributions was significantly positively related to team innovation. Thus, these two dimensions of teamwork quality cancel each other out in the equation when combined as one construct (i.e., teamwork quality). The second study makes an important contribution to the research field, as a call has recently been made for more studies on the effects of team-centric leadership and team processes on work-related outcomes (Kozlowski, Mak, & Chao, 2016). Thus, this study addresses this research gap by investigating leadership and processes at the team-level to achieve a better understanding of the team-level factors influencing teamwork and work-related outcomes in scientific teams.

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Part II: The Present Research

Part II is divided into Chapter 1 and Chapter 2 which present the two studies I conducted to extend the current research field on team leadership and teamwork in science. The research findings from Chapter 1 have been published in the *European Journal of Work and Organizational Psychology* while the findings from Chapter 2 have been submitted to *Group & Organization Management*.

Chapter 1

Person–supervisor fit, needs–supplies fit, and team fit as mediators of the relationship between dual-focused transformational leadership and well-being in scientific teams

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Chapter II

Fostering team innovation and learning by means of group-focused transformational leadership: The role of teamwork quality

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A shorter version of this manuscript was submitted to *Group & Organization Management*.

Fostering team innovation and learning by means of group-focused transformational leadership: The role of teamwork quality

Team innovation is an important factor for organizational effectiveness. However, fostering innovation in teams remains a major challenge for team leaders. In particular, we still have an incomplete understanding of the team processes that drive the effects of team-centric leadership on innovation. Combining the dual-focused model of transformational leadership with the teamwork quality model and frameworks for team innovation, the current study addresses this issue. Specifically, we investigated teamwork quality as a team-level mediator of the relationship between group-focused transformational leadership, team innovation, and individual team members' learning. We tested our hypotheses using lagged, multi-source data from a sample of 79 scientific teams. Our findings show that group-focused transformational leadership is positively related to team innovation and learning. Furthermore, the positive relationship between group-focused transformational leadership and learning is mediated by teamwork quality. Our study helped to clarify the team-level mechanisms underlying the effects of leadership on innovation and learning.

Keywords: group-focused transformational leadership; teamwork quality; team innovation; individual members' learning; scientific teams

Introduction

Nowadays, more than any time in the past, organizations have to foster innovation in order to ensure their competitive advantage in the marketplace (Anderson, Potočnik, & Zhou, 2014; van Knippenberg, 2017; Zhou & Hoever, 2014). Most of the innovative work in organizations is performed by teams (Anderson et al., 2014; Choi & Thompson, 2006; West, 2002). Innovation is a particularly relevant work outcome for teams in knowledge-intensive work contexts such as consulting or research and development (Anderson et al., 2014). Within these work contexts, science arguably represents the industry where innovation is most highly valued. As a consequence, there is a need to investigate the factors that foster innovation in scientific teams. Both leadership as well as team processes represent likely candidates, as they have already been investigated as key factors influencing innovation in other team contexts (Dong, Bartol, Zhang, & Li, 2017; X.-H. Wang, Fang, Qureshi, & Janssen, 2015).

Many teams in science have a team leader who directs the strategic alignment of team objectives and performance and supports team plans and actions through provision of relevant resources (Braun, Peus, Frey, & Knipfer, 2016; Braun, Peus, Weisweiler, & Frey, 2013; Peus, Braun, & Schyns, 2016). Not surprisingly, several studies have identified transformational leadership as a central factor for innovation in teams (Bai, Lin, & Li, 2016; Boies, Fiset, & Gill, 2015; Dong et al., 2017; Eisenbeiss, van Knippenberg, & Boerner, 2008; Jiang & Chen, 2018; P. Wang & Zhu, 2010). In these studies, leadership has been conceptualized and studied as leadership behaviours directed towards *individual* employees (e.g., fostering individual development). Recently, however, calls for more studies on the effects of *team-centric* leadership (e.g., leadership directed towards a team) have been made (Kozlowski, Mak, & Chao, 2016). In the same vein, Hughes, Lee, Tian, Newman, and Legood (2018) suggest in their literature review that further research about the effects of leadership on creativity and innovation at the team-level is needed. Finally, a recent study showed the importance of group-focused transformational leadership for scientific teamwork (Klaic, Burtscher, & Jonas, 2018).

Besides considering leadership at the team-level, more studies about the team processes and team-level emergent states that mediate the effects of team-centric leadership are needed (Hughes et al., 2018). The majority of studies on innovation in teams have focused on a single mediating variable, for example, team knowledge sharing (Dong et al., 2017; Jiang & Chen, 2018) or psychological safety (Hu, Erdogan, Jiang, Bauer, & Liu, 2018; Wong, Chow, Lau, & Gong, 2018). While these studies have provided many valuable insights (Hülsheger, Anderson, & Salgado, 2009), we believe that a more inclusive approach considering multiple mediating processes at the same time would be worthwhile. For one, conceptual frameworks of team effectiveness propose that high-quality teamwork consists of several simultaneously occurring team processes (Hoegl & Gemuenden, 2001; Salas, Shuffler, Thayer, Bedwell, & Lazzara, 2015). This is also reflected in the literature on team innovation which suggests that multiple team processes are responsible for transforming individual members' knowledge and skills into innovative ideas and products (Gebert, Boerner, & Kearney, 2010; West, 2002; West & Anderson, 1996). Furthermore, these team processes and team-level emergent states may interfere with each other which is why we need to investigate multiple factors simultaneously (Salas et al., 2015).

The current study aims to address these two issues – more research on team-centric leadership and the need to investigate several team processes simultaneously. To that end, we combine the dual-focused model of transformational leadership (X.-H. Wang & Howell, 2010) with the teamwork quality model (TWQ; Hoegl & Gemuenden, 2001) and frameworks for team innovation (Gebert et al., 2010; West, 2002; West & Anderson, 1996). Specifically, we propose that teamwork quality, which is composed of different team processes (i.e., communication quality and balance of member contributions) and team-level emergent states (i.e., cohesion and mutual support), mediates the relationship between group-focused transformational leadership and team innovation. Team leaders can improve the perceived quality of teamwork and team interactions by leading their teams in a transformational way, and thus contribute to higher innovation. In addition, we were also interested in the effect of these processes on individual team members' learning, which constitutes another important outcome for teams in the knowledge-intensive work context (Hoegl & Gemuenden, 2001; Yoon & Kayes, 2016).

The purpose of the current study is twofold: First, we focus on how team-centric leadership (i.e., group-focused transformational leadership) – as opposed to individual-centric leadership – affects team innovation and individual team members' learning. This is important, because – despite the plethora of useful insight generated by individual-centric leadership research – fostering innovation in teams remains a major challenge for team leaders (Anderson et al., 2014). As a result, calls for more research on team-centric leadership have been made (Hughes et al., 2018; Kozlowski et al., 2016). Against this background, the current study aims to complement individual-centric research on leadership and innovation that promises to provide novel insights into the factors that drive team innovation. Secondly, we increase our knowledge of the processes that transmit the effects of group-focused transformational leadership in teams. Specifically, we propose that teamwork quality functions as a mediator of the relationship between group-focused transformational leadership and team innovation and individual team members' learning. In doing so, we aim to increase our understanding of the team dynamics underlying innovation and learning.

Theory and hypotheses

Teams in science

In the current study, we focus on scientific teams as an example of teams working in knowledge-intensive work contexts, because these teams need to show a high degree of innovation and learning to accomplish their goals. After all, generating knowledge is the essence of scientific endeavours. Furthermore, there has been a continuous shift from individual-based to team-based work structures in the scientific work context (Cooke & Hilton, 2015; Vabø, Alvsvåg, Kyvik, & Reymert, 2016). The increase in teamwork in science is a result of the changing environment of scientific work: Performing research has become more complex and challenging, as scientific knowledge and methodology are advancing at a fast rate (Cooke & Hilton, 2015). As a result, scientists are increasingly joining with colleagues in collaborative research to cope with these challenges.

As team-based work structures are increasing within the scientific work context, team processes must be considered as determinants of work outcomes in scientific teams (Lee, Walsh, & Wang, 2014). Leaders of scientific teams need to show specific leadership behaviours at the team-level to foster collaboration between team members. This is a challenging task because of the specific issues in the scientific work context such as mixed-motive situations (i.e., individual goals are in conflict with team goals) and strong competition between team members (e.g., get recognized for their contribution; Klaic et al., 2018).

Outcomes for teams in science: innovation and learning

In order to investigate the effectiveness of team-centric leadership and team dynamics in scientific teams, context-specific outcomes need to be investigated. In knowledge-intensive work contexts, team innovation performance and individual team members' learning represent important outcome variables (Anderson et al., 2014; Hoegl & Gemuenden, 2001).

In line with recent literature promoting a more holistic view of idea generation and implementation as cyclical, recursive processes (Anderson et al., 2014), we define team innovation as an outcome or product "of attempts to develop and introduce new and improved ways of doing things." (Anderson et al., 2014; p. 1298). This implies that team innovation involves both creative processes such as idea generation and innovative processes such as idea implementation. Consequently, we use the terms team creativity and team innovation interchangeably throughout this manuscript. In knowledge-intensive work contexts such as science, it is crucial that teams generate and implement new ideas (Cooke & Hilton, 2015; Vabø et al., 2016). Members of scientific teams need to show creative and innovative behaviours to formulate theories, develop new methods, and find solutions for emerging problems.

In the context of knowledge-intensive teamwork, individual team members' learning is another important outcome (Hoegl & Gemuenden, 2001). Generating novel ideas and discussing their implementation in a team stipulates learning processes, as team members can benefit from exchanging knowledge, skills, and expertise (Gong, Kim, Lee, & Zhu, 2013; Lee et al., 2014; Liu, Keller, & Shih, 2011). These newly acquired knowledge and skills can in turn be put to use in future team projects and thereby increase team effectiveness (Hoegl & Gemuenden, 2001; Yoon & Kayes, 2016). Consequently, we investigated both team innovation and individual team members' learning as important outcomes in scientific teams.

Promoting innovation and learning in scientific teams

Leaders of scientific teams face significant challenges when trying to promote creative and innovative processes within their teams (Anderson et al., 2014). Recently, many studies have demonstrated effects of various leadership behaviours including ambidextrous leadership (Zacher & Rosing, 2015), ethical leadership (Chen & Hou, 2016), and transformational leadership (Boies et al., 2015) on team innovation. As useful as these approaches are, they mostly focused on leadership behaviours directed towards *individual* employees thereby neglecting team-centric leadership. This is a problem because team-centric leadership – i.e., leadership behaviours directed towards a team as a whole instead towards only individual team members (X.-H. Wang & Howell, 2010) – has been shown to have unique and differential effects on a number of team outcomes (Jiang & Chen, 2018; Klaic et al., 2018; Li, Mitchell, & Boyle, 2016). As a consequence, scholars have called for more team-centric leadership research (Kozlowski et al., 2016), particularly in the context of innovation (Hughes et al., 2018).

The difference between individual-level and team-centric leadership is especially relevant in scientific teams, which are characterized by competing goals and needs (i.e., by a mixed-motive situation): Although members of a team share common team-level goals and needs (e.g., finishing a research project successfully and efficiently), they also have competing individual goals and needs (e.g., being first authors on as many papers as possible). As a result, considering team-level goals in addition to individual-level goals is a main challenge for leaders of scientific teams (Klaic et al., 2018).

Dual-focused model of transformational leadership

Most leadership models and theories have conceptualized leadership as behaviours directed towards individual employees. Transformational leadership is traditionally conceptualized as a specific type or style of interaction between a leader and an individual employee (e.g., individualized consideration; Avolio & Bass, 1991). There is a vast amount of studies that have investigated the effects of transformational leadership behaviours directed towards individual employees on work experiences and behaviours of individual employees (see for example Banks, McCauley, Gardner, & Guler, 2016; Hoch, Bommer, Dulebohn, & Wu, 2018). Recent work in this field, however, proposes that team-centric leadership should also be considered (Hughes et al., 2018; Kozlowski et al., 2016; X.-H. Wang & Howell, 2010). In the same vein, X.-H. Wang and Howell (2010) proposed a multilevel framework of transformational leadership by differentiating transformational leadership.

The framework of X.-H. Wang and Howell (2010) distinguishes between leadership behaviours directed towards individual team members and leadership behaviours directed to a team as a whole. Transformational leadership at the individual-level (i.e., individual-focused transformational leadership) is a type of leadership behaviour that aims to empower individual employees to reach their full potential, to develop their knowledge, skills and abilities, and to increase their self-efficacy (X.-H. Wang & Howell, 2010). By contrast, transformational leadership at the team-level (i.e., group-focused transformational leadership) is a type of leadership behaviour that aims to communicate the importance of a shared consensus regarding team goals, to develop shared values and standards within the team, and to foster collaboration among team members (X.-H. Wang & Howell, 2010). Moreover, whereas leadership on the individual-level involves satisfaction of individual needs (e.g., providing feedback), leadership on the team-level involves satisfaction of team members' needs for effective teamwork (X.-H. Wang & Howell, 2010).

As of today, the empirical evidence about effects of team-centric leadership on team processes and outcomes is still scarce (Hughes et al., 2018; Kozlowski et al., 2016), particularly regarding its effects on team innovation and learning in teams (Hughes et al., 2018). Consequently, the current study aims to clarify the effects of group-focused transformational leadership on team innovation and individual team members' learning. X.-H. Wang and Howell

(2010) define three dimensions of group-focused transformational leadership: Emphasizing group identity, communicating a group vision, and team-building.

Group-focused transformational leadership in knowledge-intensive teams

Initial studies suggest that group-focused transformational leadership does affect team outcomes in knowledge-intensive teams. For example, in research and development teams, group-focused transformational leadership was positively related to group performance, helping behaviour (X.-H. Wang & Howell, 2010), and to collective efficacy at the group level (X.-H. Wang & Howell, 2012). Moreover, in scientific teams, group-focused transformational leadership was positively related to job satisfaction and negatively related to work-related strain (Klaic et al., 2018).

A recent study has even related group-focused transformational leadership to knowledge sharing and team creativity in a sample of research and development teams (Dong et al., 2017). This study highlights the importance of group-focused transformational leadership in fostering innovation in knowledge-intensive work contexts. In the current study, we built on Dong's et al. (2017) findings and extend them by a) focussing on scientific teams, b) investigating multiple team-level processes and emergent states simultaneously, and c) considering team learning as an additional outcome.

Building on this research, we propose that group-focused transformational leadership fosters team innovation. Group-focused transformational leadership implies that team leaders emphasize identification with the team, communicate a vision for the team, and resolve conflicts among team members. Importantly, these aspects of group-focused transformational leadership are considered to be key factors for team innovation in several frameworks of team innovation. For example, Gebert et al. (2010) propose that fostering a collectivistic culture (e.g., collective team identification) is a crucial factor for enhanced innovation performance in teams. Additionally, the team climate for innovation framework by Anderson and West (1998) highlights the importance of a common vision. West (2002) emphasizes the need to manage conflicts in teams effectively, and proposes that for fostering team innovation, teams need to develop integration skills, which include the skill to communicate openly and supportively. Accordingly, we hypothesize the following:

Hypothesis 1. Team members' perceptions of supervisors' group-focused transformational leadership are positively related to supervisory ratings of team innovation.

Furthermore, we propose that group-focused transformational leadership promotes individual team members' learning. Specifically, we argue that group-focused transformational leadership has a positive effect on learning by creating a safe learning environment, for example, through managing conflicts and promoting team-building activities (cf. Anderson & West, 1998). A psychological safe environment is crucial for individual team members' learning, because in such an environment, team members believe that making mistakes is part of the learning process and that other team members will offer help and feedback instead of punishment or resentment (Edmondson, 1999, 2004). In line with this notion, participative safety has been linked to learning in teams (Edmondson, 2003; Edmondson & Roloff, 2009; Nembhard & Edmondson, 2006). Moreover, we argue that by fostering team identification, leaders can also facilitate learning processes in their teams. For example, van der Vegt and Bunderson (2005) show that expertise diversity positively affected team learning in teams with high identification. By contrast, when identification with the team was low, expertise diversity had a negative effect on team learning. In sum, we hypothesize the following:

Hypothesis 2. Team members' perceptions of supervisors' group-focused transformational leadership are positively related to individual team members' learning.

Teamwork quality as mediator

Besides establishing a relationship between team-centric leadership behaviours and work-related outcomes in teams, research needs to investigate the underlying mechanisms of the leadership-outcomes relationships in order to get a full understanding of how exactly team-centric leadership relates to work-related outcomes in teams. Especially for the link between team-centric leadership and team innovation, more studies uncovering the processes leading to higher team innovation are needed (Anderson et al., 2014). In particular, we state a need for team innovation research that considers multiple team-level processes and emergent states simultaneously.

The team-level processes leading to enhanced team innovation performance are increasingly receiving attention in the literature (Hughes et al., 2018). Most of the studies that investigated the team-level processes as mediators of the leadership-innovation relationship focused on a single team-level process (e.g., team knowledge sharing) rather than looking at multiple team processes simultaneously. However, effective teamwork does not only depend on a high amount of team knowledge sharing (Dong et al., 2017; Jiang & Chen, 2018). Nor is psychological safety (Hu et al., 2018; Wong et al., 2018) as a single mechanism sufficient enough to explain the effects of team-centric leadership on work-related outcomes in teams. Researchers in the field of teamwork such as Salas et al. (2015) point out, that multiple team processes and team-level emergent states shape the quality of teamwork and thus team effectiveness.

Against this background, the construct teamwork quality by Hoegl and Gemuenden (2001) offers a promising approach to further our understanding. Teamwork quality aims to define what constitutes high quality of interactions in teams, and how teamwork quality affects both team success as well as personal success such as learning. Hoegl and Gemuenden (2001) identified six dimensions for teamwork quality, of which the following four dimensions are particularly relevant for innovation[1]: communication, balance of member contributions, mutual support, and cohesion. High communication quality in teams can be achieved when sufficient time is spent communicating (frequency) and when informal communication (e.g., spontaneously initiated contacts) prevails over formal communication (e.g., scheduled meetings). Moreover, high communication quality in teams can be achieved when team members are able to communicate directly with all other team members (structure) and when team members share their information openly with each other. In terms of balance of member contributions, it is important that every team member is able to contribute his/her task-relevant knowledge and experience to the team. Regarding mutual support, it is crucial that team members hold a cooperative frame of mind instead of a competitive one, so that team members support each other. In terms of cohesion, team members need to have an adequate level of desire to remain in the team and engage in collaborative work.

Teamwork quality has been linked to positive outcomes – for the team as whole and for individual members – in a number of studies. In a study of Lindsjørn, Sjøberg, Dingsøyr, Bergersen, and Dybå (2016), teamwork quality was positively related to team performance and individual team members' learning. In a study of Hoegl and Gemuenden (2001), teamwork quality was positively related to team performance (e.g., teams' adherence to schedule and budget) and individual team members' learning. Thus, teamwork quality affects work-related outcomes such as performance and learning in teams positively. Furthermore, in a study of Cha, Kim, Lee, and Bachrach (2015), teamwork quality was the explanatory mechanism behind the positive relationship between transformational leadership and inter-team collaboration. Thus, teamwork quality also promotes collaboration between different teams within an organization and is in turn affected by group-focused transformational leadership.

Building on this research, we propose that teamwork quality transmits the hypothesized effects of group-focused transformational leadership on team innovation and individual team members' learning in scientific teams. Scientific teamwork requires exchange of knowledge, skills and abilities (KSAs) between the members of a team (Lee et al., 2014; Liu et al., 2011; Wuchty, Jones, & Uzzi, 2007) and thus – in particular – effective communication patterns (Hirst & Mann, 2004), balance of member contributions, and mutual support (Hoegl & Gemuenden, 2001). As these processes constitute key elements of teamwork quality, we argue that teamwork quality is particularly relevant for scientific teams.

Teamwork quality can be affected by leadership behaviours, as a leader may want to improve the quality of teamwork to ensure effective interaction patterns between team members. Group-focused transformational leadership, which encompasses emphasizing group identity, communicating a group vision, and team-building, may enhance the perceived quality of teamwork. By emphasizing group identity and by communicating a group vision, leaders can affect mutual support (Braun et al., 2013; Eisenbeiss et al., 2008) and cohesion (Raes et al., 2013; Y.-S. Wang & Huang, 2009) positively. Further, by carrying out team-building activities, leaders may solve problems regarding communication and balance of member contributions, and foster mutual support and cohesion (Aga, Noorderhaven, & Vallejo, 2016; García-Morales, Jiménez-Barrionuevo, & Gutiérrez-Gutiérrez, 2012). Team-building activities focus on solving mixed-motive situations, clarifying roles, and improving interpersonal processes and team problem solving to ensure team functioning (Aga et al., 2016).

Teamwork quality in turn may affect team innovation performance: communication and balance of member contributions are key to enhancing team innovation performance, because team members share knowledge openly and try to include information of all team members during discussions (Dong et al., 2017; Hoegl & Gemuenden, 2001). Open communication and balance of member contributions promotes creative and innovative processes in teams, because – similar to hidden-profile situations – all relevant information for task completion is shared (Dong et al., 2017). The team climate for innovation framework by Anderson and West (1998) highlights the importance of participative safety in order to promote team members' feelings of being "able to propose new ideas and problem solutions in a non-judgemental climate" (p. 240). Mutual support and cohesion are important for team innovation performance as well, because team members need to support each other in cases of difficulties during task completion. The willingness to contribute to the success of team projects may be affected by the amount of cohesion perceived by team members. West (2002) and Gebert et al. (2010) propose that these processes may be important for knowledge generation and integration in teams. Thus, we propose that teamwork quality mediates the relationship between group-focused transformational leadership and team innovation.

> **Hypothesis 3** Teamwork quality mediates the positive relationship between team members' perceptions of supervisors' group-focused transformational leadership and supervisory ratings of team innovation.

In addition, teamwork quality positively affects individual team members' learning (Hoegl & Gemuenden, 2001). Open communication and balance of member contributions maximize individual team members' learning, because these processes ensure that knowledge is openly shared within the team (Anderson & West, 1998). Mutual support and cohesion also contribute to individual team members' learning, as they enhance the willingness to share knowledge, skills and abilities with other team members (Gebert et al., 2010; West, 2002). In addition, these team processes and emergent states may affect the climate the team is operating in: Open communication, balance of member contributions, mutual support and cohesion affect the amount of perceived participative safety in teams positively and thus, also indirectly affect individual team members' learning (Edmondson, 1999, 2004; Edmondson & Roloff, 2009). In sum, we propose that teamwork quality mediates the relationship between group-focused transformational leadership and individual team members' learning.

> **Hypothesis 4.** Teamwork quality mediates the positive relationship between team members' perceptions of supervisors' group-focused transformational leadership and individual team members' learning.

In sum, we propose a multilevel model of team leadership in scientific teams (Figure 1), which draws on the dual-focused model of transformational leadership (X.-H. Wang & Howell, 2010), the teamwork quality model (Hoegl & Gemuenden, 2001), and research on team innovation (Anderson & West, 1998; Gebert et al., 2010; West, 2002). Our model aims to clarify the role of different team processes as mediators of the relationships between group-focused transformational leadership and innovation and learning in teams.

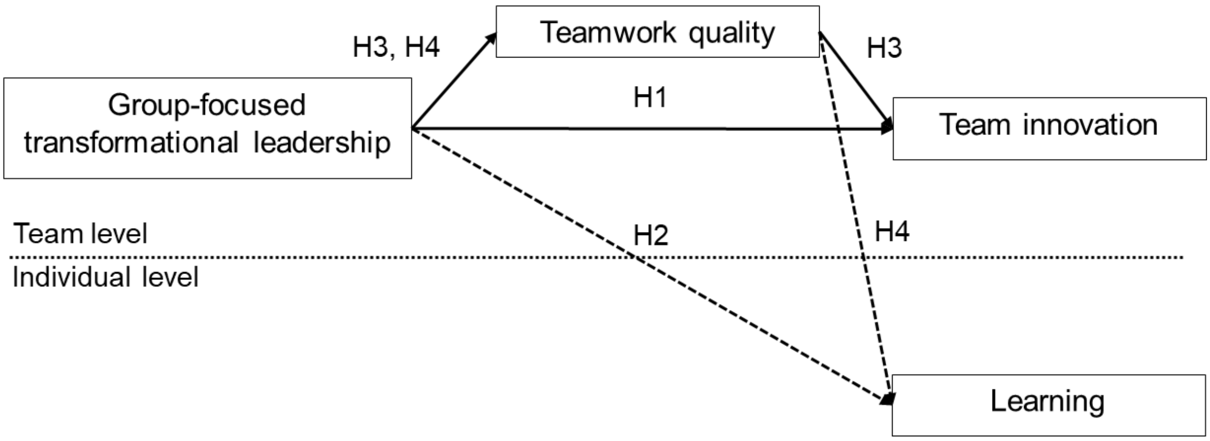

Figure 1. Multilevel model of transformational leadership, teamwork quality, team innovation and individual team members' learning. H = Hypothesis. Dashed lines indicate cross-level relations.

Method

Participants and procedure

Of over 300 teams invited to take part in the study, 79 teams from several universities in [countries withheld for blind review] participated in this study. Team members were mostly working interdependently on several research projects. The data for this study comprises ratings of 235 team members and 64 team leaders. Team members were part of the scientific staff (e.g., junior and senior researchers). Members working under the supervision of the same team leader were considered a team. The average number of members per team was 7.9 (*SD* = 4.3) ranging from 2 to 9 members per team. Importantly, not all team members participated in the surveys. Average team tenure was 40 months (*SD* = 26.7) and team members were on average 36 years old (*SD* = 8.3). 54% of the members were women. Team leaders were mainly professors or principal investigators of a research project. They were on average 51 years old (*SD* = 9.3), and 20% of the leaders were female.

Data collection from team members and team leaders took place at two measurement time points (T1, T2), separated by approximately four to six weeks in 2016 (i.e., temporally lagged survey design; see Venkataramani, Le Zhou, Wang, Liao, & Shi, 2016). The independent variable group-focused transformational leadership was assessed at T1. The mediator variable teamwork quality and the dependent variables team innovation and individual team members' learning were assessed at T2. Surveys were administered online. Team leaders received an e-mail invitation accompanied by a cover letter explaining the purpose of the study and assuring anonymity. Team leaders were asked to forward the request for participation in the study to their scientific team members. Only 15 team leaders did not fill out the questionnaire due to heavy workload (e.g., many deadlines).

Measures

Survey items were drawn from existing literature on work and organizational psychology to ensure construct validity. Questionnaires were available in English and in [language withheld for blind review]. As some of the survey items and scales were available in English only, items had to be translated and back-translated by two bilinguals. Accounting for other potential influences on team innovation and individual members' learning, we controlled for team size, team duration, task interdependence[2], age and gender.[3] Team and individual characteristics such as team size and gender have been found to influence team performance and employees' learning (Bernerth & Aguinis, 2016).

Group-focused transformational leadership

Group-focused transformational leadership was measured with the group-focused transformational leadership subscale from the Dual-Level Transformational Leadership Scale (X.-H. Wang & Howell, 2010). Participants rated their team leaders' group-focused transformational leadership (16 items) on a 5-point scale, with responses ranging from 1 (*not at all*) to 5 (*frequently, if not always*). A sample item for group-focused transformational leadership is "My direct supervisor encourages team members to take pride in our team". The scale had excellent reliability (Cronbach's α = .94).

Teamwork quality

Teamwork quality was measured with the Teamwork Quality (TWQ) scale by Hoegl and Gemuenden (2001). As mentioned earlier, we focused on the four subscales most relevant for innovation and learning: communication, balance of member contributions, mutual support, and cohesion. Team members rated their perception of teamwork quality (27 items) on a 5-point scale, with responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item for teamwork quality is "The team members help and support each other as best they could". The scale had excellent reliability (Cronbach's α = .93).

Team innovation

Team leaders rated team innovation using the scale by Zhou and George (2001). They rated their team's innovation performance (13 items) on a 5-point scale, with responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item for team innovation is "The members of my team develop adequate plans and schedules for the implementation of new ideas." (Cronbach's $\alpha = .92$).

Individual team members' learning

Individual team members' learning was measured with the scale from Yoon and Kayes (2016). Team members rated their learning (6 items) on a 5-point scale, with responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item for individual team members' learning is "I am able to acquire important know-how through my project(s)" (Cronbach's $\alpha = .80$).

Data augmentation, analytic strategy and levels of analysis

A mixed methods approach was chosen as an analytic strategy, because we proposed relationships between leadership behaviours, teamwork quality and outcomes at team (Level 2) and individual-level (Level 1; Fig. 1). We tested the main hypotheses by applying multiple linear regression analysis (H1) and multilevel modelling (H2) with the lme4 package (Bates, Mächler, Bolker, & Walker, 2015) of the statistical software R (R Core Team, 2016). We specified random intercept models and compared them to random intercepts and slopes models with chi-square tests, whereby the random intercept models fitted best. We analysed the requirements for linear mixed models (i.e., homoscedasticity, normal distribution of residuals) as well. We tested the mediation hypotheses (H3 and H4) with the mediation package in R (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014).

We calculated $r_{WG(J)}$ as a measure of agreement within teams, interclass correlation (ICC1), and F-tests indicating whether average scores differed significantly across teams (Bliese, 2000), to test if the mixed methods approach and the aggregation of variables to the team-level were appropriate for further analysis. As the ICC1 value for individual team members' learning (.12) was significant ($F(78,156) = 1.41$, $p<.05$), we proceeded with the mixed methods approach as the primary analytic strategy. For group-focused transformational leadership, $r_{WG(J)}$ was .86, ICC1 was .21, $F(78,156) = 1.78$, $p<.01$. For teamwork quality, $r_{WG(J)}$ was .98, ICC1 was .30, $F(78,156) = 2.27$, $p<.01$. These results indicate, that team membership explained considerable variance in individual ratings of learning, group-focused transformational leadership, and teamwork quality. Overall, our results support the aggregation of the individual-level measures of group-focused transformational leadership and teamwork quality for further analyses.

To account for potential problems regarding common method variance (CMV), we applied both procedural remedies before data collection and statistical remedies after data collection (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). First, we separated the measurement of the independent and dependent variables (a) temporally by assessing the variables at two time points and (b) source-related by surveying team members as well as team leaders. Further, we performed partial correlation procedures to test for CMV by partialling out a marker variable (Lindell & Whitney, 2001; Podsakoff et al., 2003). We chose post hoc the variable "external collaboration" as the marker variable, as it is theoretically unrelated to the variables in our model. Team members rated their amount of collaboration with researchers outside the team (1 item, "Myself and/or other team members collaborate with external researchers") on a 5-point scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). The analyses indicated that CMV was not an issue.[4]

Scale evaluation

We used confirmatory factor analysis (CFA) to establish discriminant validity of the three self-report scales (i.e., group-focused transformational leadership, teamwork quality, and individual team members' learning). For this purpose, we employed the lavaan package (Rosseel, 2012) of the R software (R Core Team, 2016) and used MLM estimation – a maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled tests statistic: The results revealed that a three-factor model, in which items associated with each construct loaded onto distinct factors, had an acceptable fit, ($\chi^2 = 2536.47$, $df = 986$; RMSEA = .08, SRMR = .08; CFI = .77). In this model, all item loadings from the items to their latent factors were significant at $p < .05$. To further establish discriminant validity, we compared the three-factor model to different alternative models. For each comparison, the original three-factor model provided superior fit (see Table 1). These results offer evidence of discriminant validity between the latent constructs.

Table 1. Comparison of measurement models for study variables

Model description	X^2	*df*	ΔX^2	RMSEA [90% CI]	SRMR	CFI
Three-factor model	2536.47	986	-	.078 [.073, .082]	.080	.773
Two-factor model: GTFL and TWQ as one factor, and Lear as one factor	3550.01	988	1013.5***	.102 [.098, .106]	.108	.609
One-factor model	3843.69	989	1307.2***	.108 [.104, .112]	.104	.562

Note. GTFL = group-focused transformational leadership; TWQ = teamwork quality; Lear = individual team members' learning; ΔX^2 = Satorra-Bentler scaled differences; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual; CFI = comparative fit index. $N = 235$;
* $p < .05$, ** $p < .01$, *** $p < .001$.

Note that the CFI values in all models were below acceptable fit. To address the suboptimal CFI, we performed another set of CFAs using the item parceling approach, as our dataset did not provide ideal conditions (i.e., relatively small sample size in combination with a large number of parameters to be estimated) for assessing CFA (Little, Rhemtulla, Gibson, & Am Schoemann, 2013; Marsh, Hau, & Wen, 2004). We created 9 parcels for the constructs used in this study to increase the power of latent variable models: three parcels for group-focused transformational leadership, four parcels for teamwork quality, and two parcels for individual team members' learning. Item parceling was based on theoretical considerations as well as on item content. For example, according to X.-H. Wang and Howell (2010) group-focused transformational leadership is composed of three dimensions. Consequently, we created three parcels for group-focused transformational leadership based on this theoretical rationale. We compared our three-factor model to different alternative models (see Table 2). Similar to the previous analysis, for each comparison, the three-factor model provided superior fit. Importantly, as opposed to the unparceled solution, CFI values were much improved, and the model showed a good fit overall ($\chi^2 = 48.96$, $df = 24$; RMSEA = .06, SRMR = .04; CFI = .98). Thus, we concluded that our hypothesized three-factor model fitted the data best.

Table 2. Comparison of measurement models for study variables (after item parceling)

Model description	X^2	*df*	$\Delta\chi^2$	RMSEA [90% CI]	SRMR	CFI
Three-factor model	48.96	24	-	.063 [.033, .092]	.035	.979
Two-factor model: GTFL and TWQ as one factor, and Lear as one factor	276.17	26	227.2***	.200 [.177, .224]	.085	.774
One-factor model	302.68	27	253.7***	.206 [.184, .230]	.093	.752

Note. GTFL = group-focused transformational leadership; TWQ = teamwork quality; Lear = individual team members' learning; $\Delta\chi^2$ = Satorra-Bentler scaled differences; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual; CFI = comparative fit index. $N = 235$;
* $p < .05$, ** $p < .01$, *** $p < .001$.

Results

The means, standard deviations, and correlations of independent and dependent variables are reported in Table 3. It is worth mentioning that the correlations between teamwork quality and team innovation are unexpectedly low and not significant.

Table 3. Means, standard deviations, and correlations of study variables (all on Level 1).

	M	*SD*	1	2	3
1. GTFL[a]	3.24	.83			
2. TWQ[a]	3.89	.49	.56**		
3. T-Inno[b]	3.97	.51	.16*	.09	
4. Lear[a]	4.11	.51	.33**	.43**	.11

Note. GTFL = group-focused transformational leadership, TWQ = teamwork quality, T-Inno = team innovation, Lear = individual team members' learning. $N = 235^{a}$; $N = 183^{b}$;
* p<.05, ** p<.01 (two-tailed).

Hypothesis testing

The results of the linear regression and multilevel modelling analyses predicting team innovation and individual team members' learning are reported in Table 4. Hypothesis 1 predicted a significant relationship between team perceptions of supervisors' group-focused transformational leadership and supervisors' ratings of team innovation. As expected, group-focused transformational leadership was positively related team innovation ($b = .18$, $SE = .06$, $t(64) = 2.84$, 95% CI = [0.06; 0.31], $p<.01$). Thus, Hypothesis 1 was fully supported.

Hypothesis 2 predicted a significant cross-level relationship between team perceptions of supervisors' group-focused transformational leadership and individual team members' learning. As expected, group-focused transformational leadership was positively related to individual team members' learning ($b = .23$, $SE = .06$, $t(235) = 3.53$, 95% CI = [0.10; 0.35], $p<.01$). Thus, Hypothesis 2 was fully supported.

Table 4. Results of multilevel analyses predicting team innovation and individual learning.

	team innovation		learning	
	b	*SE*	*b*	*SE*
(Intercept)	3.15**	0.31	3.80**	0.21
Level 1				
age	0.00	0.02	0.00	0.00
gender (male)	-0.14	0.07	-0.10	0.06
Level 2				
team size	0.03	0.01	-0.00	0.01
team duration	0.00	0.00	0.00	0.00
task interdep.	-0.02	0.04	0.07	0.04
GTFL	0.18**	0.06	0.23**	0.07
TWQ	0.00	0.12	0.37**	0.12

Note. task interdep. = task interdependence; GTFL = group-focused transformational leadership; TWQ = teamwork quality; *b* = estimate for linear mixed model; *SE* = standard errors; Level 1: *N*=235; Level 2: *N*=79.

* p < .05, ** p < .01 (two-tailed).

Hypothesis 3 predicted that teamwork quality significantly mediates the relationship between team perceptions of supervisors' group-focused transformational leadership and supervisors' rating of team innovation. The significant relationship between group-focused transformational leadership and team innovation had already been established in testing Hypothesis 1 (i.e., Step 1). Following the three-step mediation model approach (Baron & Kenny, 1986), we predicted the mediator teamwork quality from the mean-centred antecedent group-focused transformational leadership (i.e., Step 2). The relationship between group-focused transformational leadership and teamwork quality was significant ($b = .36$, $SE = .03$, $t(64) = 10.59$, 95% CI = [0.30; 0.43], $p<.01$). To establish the mediation effect, we regressed the outcome team innovation from the mean-centred antecedent group-focused transformational leadership, while controlling for the mediator teamwork quality (i.e., Step 3). Contrary to our prediction, the relationship between teamwork quality and team innovation was not significant ($b = .004$, $SE = .12$, $t(64) = 0.03$, 95% CI = [-0.23; 0.24], $p>.05$,). To explicitly test the mediation effect, we used the mediate-package in R (Tingley et al., 2014). By applying the mediate function in R, the mediation effect (i.e., Average Causal Mediation Effects; ACME) of teamwork quality could neither be confirmed (ACME = 0.002, 95% CI [-0.07; 0.08], $p>.05$). Thus, Hypothesis 3 was not supported.

Hypothesis 4 predicted that teamwork quality mediates the relationship between team perceptions of supervisors' group-focused transformational leadership and individual team members' learning (i.e., a Level-2 to Level-1 mediation effect). The significant relationship between group-focused transformational leadership and individual team members' learning at Level 1 had already been established in testing Hypothesis 2 (i.e., Step 1). Again, we predicted the mediator teamwork quality from the mean-centred antecedent group-focused transformational leadership (i.e., Step 2). The relationship between group-focused transformational leadership and teamwork quality was significant ($b = .29$, $SE = .04$, $t(235) = 7.88$, 95% CI [.21; .34], $p<.01$). Next, we regressed the outcome individual team members' learning from the antecedent group-focused transformational leadership, while controlling for the mediator teamwork quality (i.e., Step 3). We found that the relationship between teamwork quality and individual team members' learning was significant ($b = .37$, $SE = .12$, $t(235) = 3.11$, 95% CI [.14; .59], $p<.01$), while the direct effect of group-focused transformational leadership on individual team members' learning became non-significant ($b = .09$, $SE = .08$, $t(235) = 1.21$, 95% CI [-.05; .23], $p>.05$). This pattern suggests that teamwork quality mediates the effect of group-focused transformational leadership on individual team members' learning. By applying the mediate function in R, we could confirm the mediation effect (i.e., the average causal mediation effect; ACME) of teamwork quality (ACME = 0.11, 95% CI [-0.04, 0.19], $p<.01$). Thus, Hypothesis 4 was fully supported.

Supplementary post-hoc analyses

As teamwork quality did not mediate the relationship between team perceptions of group-focused transformational leadership and supervisory ratings of team innovation (Hypothesis 3), we performed additional post-hoc analyses. We decomposed the construct teamwork quality into its four dimensions (i.e., communication quality, mutual support, cohesion, and balance of member contributions)[5] and performed a multiple mediation analysis with the INDIRECT SPSS macro from Preacher and Hayes (2008). Our goal was to investigate potential indirect effects of the four teamwork quality dimensions separately by testing a multiple mediator model. First, we calculated $r_{WG(J)}$ and ICC1 to test, if the aggregation of the four teamwork quality dimensions was appropriate for further analysis. For communication quality, $r_{WG(J)}$ was .95 and ICC1 was .22, $F(78,156) = 1.85$, $p<.01$. For mutual support, $r_{WG(J)}$ was .93 and ICC1 was .25, $F(78,156) = 2.01$, $p<.01$. For cohesion, $r_{WG(J)}$ was .91 and ICC1 was .35, $F(78,156) = 2.58$, $p<.01$. For balance of member contributions, $r_{WG(J)}$ was .82 and ICC1 was .14, $F(78,156) = 1.47$, $p<.05$. We concluded, that aggregation of the individual-level measures of the four teamwork quality dimensions was appropriate.

Second, we predicted the mediators (a) communication quality, (b) mutual support, (c) cohesion, and (d) balance of member contributions from the antecedent group-focused transformational leadership. The relationships between group-focused transformational leadership and (a) communication quality ($b = .37$, $SE = .04$, $t(64) = 9.95$, $p=.01$), (b) mutual support ($b = .29$, $SE = .04$, $t(64) = 7.12$, $p=.01$), (c) cohesion ($b = .43$, $SE = .05$, $t(64) = 8.38$, $p=.01$), and (d) and balance of member contributions ($b = .33$, $SE = .06$, $t(64) = 5.83$, $p=.01$) were significant. To establish the mediation effects of the four teamwork quality dimensions, we regressed the outcome team innovation from the antecedent group-focused transformational leadership, while introducing the mediators (a) communication quality, (b) mutual support, (c) cohesion, and (d) balance of member contributions. The following effects were detected: The relationship between (a) communication quality and team innovation was not significant ($b = -.08$, $SE = .18$, $t(64) = -0.42$, $p=.67$). The relationship between (b) mutual support and team innovation was not significant as well ($b = .11$, $SE = .17$, $t(64) = 0.68$, $p=.50$). But the relationship between (c) cohesion and team innovation was significantly negative ($b = -.34$, $SE = .14$, $t(64) = -2.41$, $p=.02$). Additionally, the relationship between (d) balance of member contributions and team innovation was significantly positive ($b = .39$, $SE = .10$, $t(64) = 3.72$,

p=.01). Considering the bootstrap results for indirect effects, it becomes apparent that the significance of the mediation effects of (c) cohesion (*ab* = -.16, BCa CI [-.31, -.03]) and (d) balance of member contributions (*ab* = .13, BCa CI [.04, .27]) were confirmed. Notably, it seems that cohesion with its negative relation to team innovation and balance of member contributions with its positive relation to team innovation cancel each other out when combined as one construct (i.e., teamwork quality). This pattern of findings could explain why teamwork quality as a whole did not mediate the effect of group-focused transformational leadership on team innovation.

Discussion

The results of our analyses support three out of four hypotheses. The relationships between team perceptions of supervisors' group-focused transformational leadership and both team innovation and individual team members' learning were positive and significant. Thus, team-centric leadership such as group-focused transformational leadership has positive effects on team- and individual-level outcomes in teams from knowledge-intensive work contexts. As such, our study contributes to the literature on leadership and innovation by addressing this call on more team-centric leadership studies (Hughes et al., 2018; Kozlowski et al., 2016) and providing results on the effects of team-centric leadership on work outcomes in scientific teams.

Moreover, our study addresses the call to investigate multiple team processes simultaneously (Salas et al., 2015) such as teamwork quality which is composed of multiple team processes and team-level emergent states. Thus, this study increases our understanding of the team dynamics underlying innovation and learning. Our results show that teamwork quality mediated the relationship between group-focused transformational leadership and individual team members' learning. This means that higher levels of group-focused transformational leadership, which includes emphasizing group identity, communicating a group vision, and promoting team-building, were associated with higher levels of individual team members' learning. The likely mechanism behind this relationship is that transformational leadership relates to higher teamwork quality: When team members communicate effectively with each other, foster balance of member contributions during discussions, stick together and support each other during task completion, they promote individual team members' learning by sharing knowledge and skills and discussing new ideas and innovative approaches. Because learning in teams promotes professional and personal development, it may in turn affect the success of future team projects positively (Hoegl & Gemuenden, 2001; Yoon & Kayes, 2016).

As mentioned, perceptions of supervisors' group-focused transformational leadership were positively related to supervisors' rating of team innovation. However, teamwork quality did not mediate this relationship. Supplementary post-hoc analyses showed that balance of member contributions as an aspect of teamwork quality was positively related to team innovation, whereas cohesion as another aspect was negatively related to team innovation. A likely interpretation is that these two dimensions of teamwork quality, namely balance of member contributions and cohesion, cancel each other out statistically when combined into a single construct. It makes sense that balance of member contributions is positively related to team innovation: Balance of member contributions is an important determinant of team innovation, as all members of a team need to be able to share their information to prevent poor group decisions due to hidden profile situations (Dong et al., 2017; Hoegl & Gemuenden, 2001).

Although team cohesion is generally considered a positive factor for team innovation (Hülsheger et al., 2009), it could be argued that – under certain conditions – high levels of cohesion might have negative effects. For one, team innovation requires divergent thinking of team members, which may be difficult to achieve when team members stick together too excessively and thus may not want to criticize each other (Brodbeck, Kerschreiter, Mojzisch, & Schulz-Hardt, 2007). For example, a high level of social cohesion may lead to the well-known phenomenon of "groupthink" (Bernthal & Insko, 1993; Janis, 1982; Zaccaro & Lowe, 1988). Hülsheger et al. (2009) posit that a high degree of cohesion fosters psychological safety in teams, which in turn enables high innovation performance. However, Bradley, Postlethwaite, Klotz, Hamdani, and Brown (2012) clearly distinguish between cohesion as an affective emergent state and psychological safety as a cognitive emergent state. They argue that psychological safety "differs from cohesion in that it facilitates, rather than discourages, constructive disagreements among members" (Bradley, Klotz, Postlethwaite, & Brown, 2013). Thus, teams may encompass a high degree of cohesion without necessarily having a high degree of psychological safety, as these are two differing constructs. This means that team members may feel attracted to each other (i.e., high social cohesion), but that does not necessarily mean that they feel free to voice ideas, opinions, and suggestions (i.e., high psychological safety). Strong social cohesion may even prohibit such voice behaviour in teams, as team members may fear to disrupt harmony within the team when engaging in critical discussions. As a result, it may be important for future research to investigate both cohesion and psychological safety in teams in order to analyse the effects on innovation performance.

Besides psychological safety, other team-level mechanisms than teamwork quality may be relevant for team innovation. Team innovation is a result of team members' divergent knowledge, skills, and abilities coming together to foster innovation (Anderson et al., 2014). Teamwork quality focuses on improving group dynamics in teams (e.g., cohesion). Even though teamwork quality suggests that multiple team-level processes such as communication and mutual support have to function appropriately within a team in order to foster teamwork and enhance team performance (Hoegl & Gemuenden, 2001), other team-level processes may be missing in the model. For example, task conflict may enhance team innovation, as a diverse set of knowledge, skills, and abilities is brought in for problem solution (Farh, Lee, & Farh, 2010). Thus, team members may be debating which ideas and approaches are more appropriate to solve a problem in the most innovative and effective way. Accordingly, task conflict improves the information-decision-making process in teams (Wit, Jehn, & Scheepers, 2013). Yet, recent research indicates that task conflict alone does not contribute to higher team performance (Bradley et al., 2013; Wit et al., 2013; Xie, Wang, & Luan, 2013). Team characteristics (e.g., personality composition) and task conflict interact to enhance team performance (Bradley et al., 2013). Nevertheless, research should focus on additional team-level processes such as positively dealing with task conflicts or team-level emergent states such as high psychological safety to uncover the mechanisms behind the team leadership and team innovation relationship.

Altogether, our results partially support our model of group-focused transformation leadership, teamwork quality, team innovation, and individual team members' learning in scientific teams, which integrated aspects of the dual-focused model of transformational leadership (X.-H. Wang & Howell, 2010), the teamwork quality model (Hoegl & Gemuenden, 2001), and frameworks for team innovation (Gebert et al., 2010; West, 2002; West & Anderson, 1996). In our additional analysis, we were able to show that some team processes may have different effects when investigating other work-related outcomes than team effectiveness. These findings point towards the importance of investigating multiple team processes and team-level emergent states simultaneously, as some factors have adverse effects on specific team-level outcomes such as team innovation.

Practical implications

The current study confirms the conclusions of previous studies that transformational leadership is a key factor for enhancing work outcomes in scientific teams (Braun et al., 2013; Braun et al., 2016; Klaic et al., 2018). In particular, our findings point towards the importance of group-focused transformational leadership and teamwork quality for higher innovation performance and individual team members' learning. Leaders of scientific teams are experts particularly for their respective research field. However, they are rarely trained or specialised for team leadership in science (Cooke & Hilton, 2015).

Thus, leaders of scientific teams need to be aware of these positive effects of group-focused transformational leadership on team functioning and team performance and accordingly need to be trained to be effective leaders. As such, leaders of scientific teams should be trained to show group-focused transformational leadership behaviours such as (a) emphasizing group identity, (b) communicating a group vision, and (c) fostering team-building activities. For example, team leaders may emphasize group identity by saying positive things about the team that make team members feel proud to be part of the team and by encouraging team members to place the interests of the team ahead of their own interests. This may be especially relevant for the scientific work context, as scientists suffer from challenging work characteristics in academia (e.g., limited promotion prospects) and may thus perceive the pressure and competition between team members difficult to bear.

Additionally, our results stress the importance of management strategies to enhance teamwork quality. High teamwork quality is achieved through high levels of communication, coordination, balance of member contributions, mutual support, effort, and cohesion (Hoegl & Gemuenden, 2001). Leaders of scientific teams should try to improve the perceived quality of teamwork by adopting group-focused transformational leadership behaviours. For example, by fostering team-building activities, leaders can improve communication and balance of member contributions besides mutual support and cohesion (Aga et al., 2016; García-Morales et al., 2012). Thus, team meetings on a regular basis should focus, besides the accomplishment of team objectives, on reflecting on the quality of interactions between team members. However, team leaders need to be aware of the negative effect of cohesion on team innovation and should promote psychological safety in teams in order to ensure constructive controversy in teams (Hu et al., 2018).

Limitations and future research

The following limitations should be kept in mind when interpreting the findings of our study: The correlational design of the current study does not allow the establishment of causal relationships between group-focused transformational leadership and work-related outcomes. Hughes et al. (2018) propose that research on the effects of leadership on creativity and innovation should apply study designs such as experimental designs, field studies or longitudinal designs in order to estimate causal models appropriately and avoid problems arising through endogeneity biases (Antonakis, Bendahan, Jacquart, & Lalive, 2010; Fischer, Dietz, & Antonakis, 2017). This issue could be addressed in an intervention study, in which randomly chosen groups of team leaders would receive group-focused transformational leadership training prior to data collection through questionnaires.

Furthermore, it could be of interest to assess how daily levels of group-focused transformational leadership are related to outcomes in team members, as recent studies suggest that the levels of transformational leadership a leader shows may vary from day to day (Breevaart et al., 2014; Diebig, Bormann, & Rowold, 2016; Tepper et al., 2018) or week to week (Breevaart, Bakker, Demerouti, & Derks, 2016). We assume group-focused transformational leadership to be a stable construct, which is modifiable through leadership training, but does not vary on a daily or weekly basis. However, this may not be the case for newly-trained team leaders, who still have to figure out, how they could adopt transformational leadership behaviours in various day-to-day or weekly situations.

Moreover, we use the terms creativity and innovation interchangeably and adopted the definition of Anderson et al. (2014) in order to define innovation performance. This definition has just recently been criticized (Hughes et al., 2018). The most important criticism relates to the fact that in previous research creativity was conceptualized as existing only as a part of an innovative process. However, innovation researchers have argued over this issue in the last decades and the debate will continue. We believe that creativity precedes innovation for the specific context of scientific teams. Thus, we defined innovation performance in accordance with the definition of Anderson et al. (2014). Further, the misunderstandings in the conceptualization of the constructs creativity and innovation have led to creativity and innovation measures, which lack construct validity and reliability (Hughes et al., 2018). We used the popular scale of Zhou and George (2001), which measures both creativity and innovation and assesses creativity and innovation as processes and products. However, the development of new tools to assess workplace creativity and innovation accurately is recommended (Hughes et al., 2018). Future research should address these issues regarding conceptualization and measurement of creativity and innovation.

Another avenue for future research would be to test our multilevel model of team-centric leadership and teamwork quality in other team contexts. Even though we had a strong emphasis on studying scientific teams, we believe that our findings may be applicable to other teams within the knowledge-intensive work context and even to teams in other work contexts, which nowadays focus increasingly on fostering innovation and learning in order to enhance organizational effectiveness and competitive advantage. For example, a strong emphasis on team-centric leadership and team processes may be important for research and development teams, but it may be important for teams in healthcare or aviation as well. For example, Schippers, West, and Dawson (2015) investigated innovation performance in teams from the health care work context, because introducing changes or innovations regarding work procedures (e.g., improved services for patients) may improve patient care. Thus, investigating innovation performance and the corresponding antecedents for high innovation performance in teams within and even outside the knowledge-intensive work context may be a promising approach for future research.

Conclusion

Our study makes several contributions to the literature on leadership and teams in knowledge intensive work context. Combining different theoretical approaches – i.e., the dual-focused model of transformational leadership, the teamwork quality model, and frameworks for team innovation and using a multilevel framework, we were able to further clarify the factors that contribute to higher innovation and learning in scientific teams. Specifically, our results show that group-focused transformational leadership is positively related to team innovation and individual team members' learning. The relationship between group-focused transformational leadership and individual team members' learning is mediated via teamwork quality. However, teamwork quality is not the explanatory mechanism behind the group-focused transformational leadership and team innovation relationship. Supplementary analyses show that two subcomponents of teamwork quality, namely cohesion and balance of member contributions, have adverse effects on team innovation performance. In sum, this study highlights the importance of investigating leadership and processes on the team-level in order to achieve a better understanding of the team-level factors influencing teamwork and work-related outcomes in teams.

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Notes

1. We excluded the two dimensions coordination and effort, as they did not seem to be significant team processes in the work context of scientific teams. High coordination quality is achieved, when teams develop clear subgoals/activities for each team member. High effort is achieved, when team members have a common understanding regarding work norms. The scientific teams in our sample did not have the need to coordinate tasks or discuss work norms explicitly. In a preliminary survey with 20 scientific team members, participants confirmed our assumptions and had difficulties answering the coordination and effort items. However, coordination and effort may be important processes in newly formed project teams and action teams. In our sample, team members were already working in their teams for 40 months at least.
2. Task interdependence was measured with a scale from van der Vegt, van de Vliert, and Oosterhof (2003). Team members rated the degree of task interdependence within their teams (3 items) on a 5-point scale, with responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item for task interdependence is "In order to complete our work, my colleagues and I have to exchange information and advice." (Cronbach's α = .80).
3. The results remain stable if these control variables are not included.
4. Results from these analyses can be obtained from the corresponding author.
5. The reliability coefficients for the four dimensions of teamwork quality are: Communication quality (Cronbach's α = .80), mutual support (Cronbach's α = .82), cohesion (Cronbach's α = .85), and balance of member contributions (Cronbach's α = .63).

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Part III: General Discussion

Part III concludes with an overview of the core findings and the contribution of my research to the broader research field. I also discuss the strengths and limitation of the research I conducted and present implications for future research and practice.

Overview of the Core Findings

Overview

The aim of my thesis was to investigate the effects of transformational leadership, person–environment fit, and teamwork quality on productivity in scientific teams (i.e., team innovation, learning and well-being). This focus was chosen because this work context differs substantially from others (Bozeman & Gaughan, 2011; Feldman & Turnley, 2004; Goastellec et al., 2013; Levecque et al., 2017; Reevy & Deason, 2014; van der Weijden et al., 2016), which makes scientific teams a unique and particularly challenging team setting (Braun et al., 2016; Peus et al., 2016). Further, team-based work structures have become prevalent in science (Cooke & Hilton, 2015; Vabø et al., 2016). However, studies investigating team leadership and group dynamics in scientific teams are lacking. The study by Braun et al. (2013) is the first to investigate the effects of transformational leadership and trust on performance and well-being in scientific teams. Thus, to close this research gap on scientific teams' productivity, I used Braun et al.'s (2013) study as a starting point and conducted two studies drawing on the dual-focused model of transformational leadership, person–environment fit theory, and the teamwork quality model. In the following sections, I first provide a summary of the studies' core findings. Second, I outline the general strengths and limitations of my research. Third and finally, I discuss the theoretical and practical implications of the research I conducted.

Chapter 1

The aim of Chapter 1 was to establish the relationship between transformational leadership and team members' well-being (i.e., job satisfaction and work-related strain) through three mediators: person–supervisor fit, needs–supplies fit, and person–group fit (i.e., team fit). The hypotheses were tested with a sample of 134 team members in 42 scientific teams at two large research universities in Switzerland using a three-wave lagged design: Transformational leadership was assessed at time one, person–environment fit at time two, and team members' well-being at time three.

Overall, the results largely supported the hypotheses: The relationship between individual-focused transformational leadership and team members' well-being was mediated by person–supervisor fit and needs–supplies fit. Additionally, group-focused transformational leadership was positively related to job satisfaction and negatively related to work-related strain. However, team fit was not the mechanism explaining the relationship between group-focused transformational leadership and well-being. I argued that one explanation for this negative finding may be that team fit is less important in explaining the effects of group-focused transformational leadership on well-being than other team processes such as communication and/or helping behaviour.

In sum, the findings of the first study highlight the importance of differentiating between transformational leadership directed towards individual team members and transformational leadership directed towards the team as a whole. It is important that leaders of scientific teams keep this in mind to deal effectively with problems arising through mixed-motive situations such as conflicting individual-level and team-level goals and needs. The first study is one of the few studies to investigate important success factors for team members' well-being in the scientific work context by combining a prominent leadership model with a central stress theory from industrial/organizational and social psychology. As such, this first study makes a strong contribution to the research field.

Chapter 2

The aim of Chapter 2 was to establish the relationship between transformational leadership and team innovation and individual team members' learning through the mediator teamwork quality. Since team fit as a team-level factor did not significantly mediate the relationship between group-focused transformational leadership and team members' well-being in Study 1, I tried to find a more suitable team-level factor as explanatory mechanism for the leadership-outcomes relationship. Thus, the second study extends the previous research on the factors positively influencing work-related outcomes in scientific teams by investigating factors at the team-level. The hypotheses were tested with a sample of 235 team members and 64 team leaders in 79 scientific teams at several research universities in Switzerland and Germany using a temporally lagged design with two measurement time points: Transformational leadership was assessed four weeks prior to teamwork quality, team innovation, and individual team members' learning.

Overall, the results supported the hypotheses: The relationship between group-focused transformational leadership and individual team members' learning was mediated by teamwork quality. Additionally, group-focused transformational leadership was positively related to team innovation. However, teamwork quality was not the mechanism explaining the relationship between group-focused transformational leadership and team innovation. Nonetheless, supplementary post hoc analyses revealed that only two dimensions of teamwork quality proved to be significant mediators for group-focused transformational leadership and team innovation relationship: Cohesion was significantly negatively related to team innovation, while the balance of member contributions was significantly positively related to team innovation. Thus, these two dimensions of teamwork quality cancel each other out when combined as one construct, teamwork quality.

In sum, the second study builds upon the findings of the first and investigates team processes and team-level emergent states through the construct of teamwork quality, which contributes greatly to explaining the effects of group-focused transformational leadership on work-related outcomes in scientific teams. The second study makes an important contribution to the research field, as a call has recently been made for more studies on the effects of team-centric leadership and team processes on work-related outcomes (Kozlowski et al., 2016). Thus, this study addresses this research gap by investigating leadership and processes at the team-level to achieve a better understanding of the team-level factors influencing teamwork and work-related outcomes in scientific teams.

Strengths of the Conducted Research

A general strength of my research is the *theory-driven approach* to investigating the success factors that determine productivity in scientific teams. In both studies, I proposed a multilevel model with transformational leadership as input factor, several indicators of person–environment fit and teamwork quality as process factors, and team innovation, learning, and well-being as output factors by integrating the dual-focused model of transformational leadership (X.-H. Wang & Howell, 2010) with (a) the person–environment fit theory (Kristof-Brown et al., 2005) and (b) the teamwork quality model (Hoegl & Gemuenden, 2001). My studies are among the first to investigate factors affecting work-related outcomes in scientific teams by integrating these prominent theories from the fields of social psychology and work and organizational psychology. Thus, I did not start with one theory or model and then investigate individual-level and team-level mediators such as trust, knowledge sharing and/or participative safety. Better, I combined the dual-focused model of transformational leadership with two established theoretical frameworks of (a) stressors and resources at the workplace driving employee behaviour (Chapter 1) and (b) the quality of interactions in teams determining team success (Chapter 2). Therefore, the current thesis extends our knowledge of the effects of transformational leadership on work-related outcomes by broadening our understanding of the mechanisms behind transformational leadership. These mediating mechanisms have been selected because they build upon theoretical frameworks that in turn are based on strong empirical evidence.

Another strength of my studies is the investigation of factors in a *multilevel framework*. Previous studies have mostly investigated individual-level factors that determine personal success, such as personality or individual competencies. This applies especially to knowledge-intensive work contexts such as science, as I indicated in the introduction of my thesis when summarizing the empirical literature on past studies on the scientific work context. However, as team-based work structures have become prevalent in many work contexts (Anderson et al., 2014; Choi & Thompson, 2006; West, 2002), research should investigate team-level factors such as team leadership and teamwork affecting team success besides individual-level factors. For example, a team leader needs to consider that he/she should show both leadership behaviours directed towards individual team members and thus towards individual need satisfaction, such as showing recognition due to a need for competence, and leadership behaviours directed towards a team as a whole and thus towards team-level need satisfaction, such as carrying out team-building activities to achieve high-quality teamwork. Recently, a call has been made to investigate team-centric leadership and team-level processes and emergent states as factors influencing work-related outcomes at the individual- and team-levels (Kozlowski et al., 2016). In line with these propositions, I investigated individual- and team-level factors influencing work outcomes in scientific teams simultaneously within a multilevel framework. Therefore, I considered the recent changes in organizations as increases in team-based work structures and the call for more team-level research, which is why my studies make a strong contribution to the research field.

I investigated teams within my studies, which is a major challenge when conducting research in organizations. I put considerable effort into acquiring as many scientific teams as possible so as to be able to test the hypotheses with an extensive data set. It took me and the students who assisted me during my research projects several months to convince leaders and members of scientific teams to participate in the studies and, most importantly, to retain them for the entire duration of the surveys. This brings me to the next point regarding the strengths of my research: the *methods applied* within my studies. I used a temporally lagged design for both studies by investigating the input, process, and output variables separately in time and thus reduced potential problems of common method bias, such as inflated relationships between variables and faulty inferences (Podsakoff et al., 2003). Additionally, I employed a multi-source data collection approach within my second study by surveying both team members and team leaders. Thus, some variables, such as teamwork quality, were assessed by team members while others, such as team innovation performance, were evaluated by team leaders. This methodological procedure allowed a reduction of common method variance (Podsakoff et al., 2003). In sum, I put substantial effort into acquiring teams rather than individual employees, retaining these teams for the duration of the entire data collection including several points of measurement, and including multiple sources by surveying team members as well as team leaders. Additionally, I performed complex statistical analysis procedures such as multilevel modelling to adequately address the complexity within my data sets (i.e., team members nested in teams). In conclusion, the effort to collect the data set needed and analyse it appropriately was very extensive and complex.

Another strength of my research is the use of a more *suitable measure* to assess individual-level and team-level transformational leadership. In response to criticism of the concept of transformational leadership and its measurement with the Multifactor Leadership Questionnaire (e.g., van Knippenberg & Sitkin, 2013), I used the dual-level transformational leadership scale by X.-H. Wang and Howell (2010) to assess transformational leadership more appropriately. In addition, this scale allows differentiation between individual-level transformational leadership behaviours and team-level transformational leadership behaviours. X.-H. Wang and Howell (2010) developed their dual-level model of transformational leadership and its associated scale in response to criticisms of the construct and measurement of transformational leadership. These criticisms culminated in van Knippenberg's and Sitkin's (2013) seminal paper in the *Academy of Management Annals*. Their criticisms are for the most part legitimate. However, I do not concur with van Knippenberg and Sitkin's (2013) final statement that "the field will be better off when it abandons the charismatic–transformational leadership concept." (p. 49). In contrast, I believe in line with critiques prior to the van Knippenberg and Sitkin (2013) paper that we need better theory and measurement to advance the concept of transformational leadership. In my opinion, X.-H. Wang and Howell (2010) did a great deal in taking these critiques seriously and advancing the theory and measurement of transformational leadership by developing the dual-focused model of transformational leadership and the dual-level transformational leadership scale. This manifests itself in the recent increases in the numbers of studies on transformational leadership, which now build upon better theories and measurement tools (Dong et al., 2017; Klaic et al., 2018; H. Liu & Li, 2018; Lorinkova & Perry, 2018; Zhang, Li, Ullrich, & van Dick, 2015). Additionally, two meta-analyses by Banks et al. (2016) and Hoch et al. (2018) have shown that emerging forms of positive leadership such as authentic leadership and ethical leadership, which have been investigated increasingly in recent years as a response to the van Knippenberg and Sitkin (2013) paper, do not explain incremental variance in the majority of outcome variables beyond transformational leadership. Furthermore, authentic leadership and ethical leadership are highly correlated with transformational leadership (>.70), pointing towards construct redundancy and the more severe issue of construct proliferation, which in addition to the replication crisis has shaken our research field.

Limitations of the Conducted Research

However, my research exhibits some limitations. First, the assumptions of the proposed multilevel models were tested on a very *specific sample* of scientific teams in higher education institutions. Team-based work structures have become prevalent in the scientific work context. Yet, studies investigating teamwork in this particular work context are lacking. Thus, we need to advance our knowledge of the factors driving productivity in scientific teams (Braun et al., 2013; Braun et al., 2016). One could argue that a vast amount of studies already investigated leadership and teamwork in samples of employees from other work contexts, such as sales, marketing, and finance and even in samples of employees from knowledge-intensive work contexts, such as research and development. However, one could also question the generalizability of these research findings for the specific work context of scientific teams, as the scientific work context differs substantially from other work contexts. Scientific team leaders and team members have to deal with contingent employment situations, conflicting role requirements, strong mixed-motive situations, and limited promotion prospects to a greater extent than in other work contexts (Feldman & Turnley, 2004; Goastellec et al., 2013; van der Weijden et al., 2016). Further, science is a particularly challenging work context, as team members suffer from high occupational stress due to these job demands, and the occurrence of mental health issues is twice as high in higher education institutions as in higher educated employees in other work contexts (Bozeman & Gaughan, 2011; Levecque et al., 2017; Reevy & Deason, 2014). Even though I advance quite convincing arguments why it is necessary to investigate the scientific work context, I do not argue that the assumptions of the proposed multilevel models from my studies may not apply to teams in other work contexts. Indeed, I argue that teams from extreme work environments such as health care, aviation, and law enforcement may also benefit from effective leadership behaviours and efficient team processes, as such action teams are characterized by higher levels of interdependence between team members and need to succeed in accomplishing their goals to save human lives (Courtright et al., 2015; Devine, 2002; Sundstrom et al., 2000; Wilson et al., 2005). In these contexts, effective team leadership and efficient teamwork are key to promoting patient health, passenger safety, and citizen protection. In sum, I believe that the assumptions of the proposed multilevel models may also apply to other team contexts, especially if teams operate in extremely demanding and stressful work environments. However, this assumption needs to be tested to confirm the generalizability of my research results to these other work contexts.

Second, concerns may be raised regarding the *absence of objective publication performance data*, even though I claim to investigate the success factors of scientific teams' productivity. As mentioned in the introduction of this thesis, scientific productivity should not be treated solely as the ratio of labour input to labour output (e.g., number of peer-reviewed papers over a period of two years). This applies to other work contexts as well; for example, it is difficult to objectively and reliably assess productivity in medical teams. Furthermore, many researchers claim that it is inadmissible to equate scientific productivity with research performance (Aguinis, Suarez-Gonzalez, Lannelongue, & Joo, 2012; Antonakis & Lalive, 2008; Bazeley, 2010; Toutkoushian, Porter, Danielson, & Hollis, 2003). Researchers debate the matter of assessing scientific teams' productivity in terms of team research performance for several reasons: First, research performance may be measured via objective data (e.g., indicators such as number of peer-reviewed publications weighted by source-normalized impact factor). However, no consensus exists on how to measure team research performance accurately (Popova et al., 2017). Additionally, comparisons between scientific teams working in diverse disciplines should be made with caution, because disciplines differ in their publication processes (e.g., in length of papers, number of authors, citation speed). Furthermore, objective data (e.g., citation counts) may only be gathered when sufficient time has passed since the survey, at the earliest after two to three years. Otherwise, data collection may result in a data set with many missing or biased values for research performance due to differences in publication and citation speed. Third, members of scientific teams need to deal effectively with conflicting role requirements, as team members need to perform research, teaching, and service duties, often concurrently. Therefore, a scientific team's productivity consists not only of a team's research performance but also of performance indicators related to other work duties such as teaching. Thus, it proved quite a challenge to find appropriate indicators for productivity in the scientific work context. I relied on common practices in the research fields of social psychology and work and organizational psychology and investigated indicators such as job performance (i.e., team innovation and learning) and well-being (i.e., job satisfaction and work-related strain) in line with Sonnentag and Frese's (2003) propositions for the operationalization of output variables in the work context. The importance of investigating "soft outcomes" such as well-being becomes even more apparent in the scientific work context, as low levels of employee well-being are a major problem in science (Levecque et al., 2017; Reevy & Deason, 2014). In both studies, I tried to assess team research performance via objective data such as number of peer-reviewed publications weighted by source-normalized impact per paper as another indicator of productivity in scientific teams. However, and as anticipated, many values were missing from my dataset, for example for teams who had not published anything at all or only a limited number of publications. Thus, I refrained from including team research performance as another indicator for scientific teams' productivity.

Third, even though I invested a great effort in performing research on a methodologically sound basis, my studies were *cross-sectional* in nature. Additionally, in the first study, data was obtained from a *single source*, scientific team members. Such data collection practices have been criticized regarding common method variance (Brannick, Chan, Conway, Lance, & Spector, 2010; Podsakoff et al., 2003). Common method variance may lead to inflated relationships between variables and thus faulty inferences, because all variables are assessed through self-report by a single source. As this was the case in my first study, reviewers commented on the issue of common method variance in my dataset and demanded that I resolve this case. Thus, I applied a range of procedural remedies before data collection and statistical remedies after data collection to account for potential common method variance (Podsakoff et al., 2003). In the first study, procedural remedies before data collection included the temporal separation of the measurement of variables through a temporally lagged design by assessing the independent variables at T1, the mediator variables at T2, and the dependent variables at T3. Statistical remedies after data collection included the execution of partial correlation procedures with a marker variable (Lindell & Whitney, 2001; Podsakoff et al., 2003). In the second study, I invested more effort in resolving the issue of common method variance by focusing more strongly on other procedural remedies before data collection. In addition to separating the measurement of the variables through a temporally lagged design, I assessed the variables through self-reports from multiple sources. Thus, I included ratings of both team members and team leaders in my second study. I demonstrated that common method variance was not an issue in either my first or second study. However, the cross-sectional design of both studies is still a major issue, as it does not allow causal conclusions to be drawn. Yet, in line with propositions from the input-process-output framework (Ilgen, Hollenbeck, Johnson, & Jundt, 2005; McGrath, 1964, 1984), I suggest that leadership as an input variable has effects on mediator variables such as person–environment fit and teamwork quality, which in turn have effects on work-related outcomes. Further, I derived my hypotheses in line with the propositions of prominent theories from social psychology and work and organizational psychology (Hoegl & Gemuenden, 2001; Kristof-Brown et al., 2005; X.-H. Wang & Howell, 2010); these have been tested and confirmed in multiple experimental investigations with student samples (see for example Kovjanic et al., 2012; Kovjanic et al., 2013). Nonetheless, in accordance with some reviewer comments, I carefully amended my wording in the manuscripts to avoid suggesting causal conclusions on the basis of cross-sectional results and mentioned this limitation in the discussion parts of my papers.

Lastly, the focus of my dissertation thesis was to investigate *success factors* of scientific teams' productivity and thus factors positively influencing work-related outcomes in scientific teams. However, I did not investigate factors for failure such as destructive leadership (e.g., abusive supervision) or dysfunctional communication patterns (e.g., knowledge withholding) in teams, as these may also appear in the scientific work context and pose a threat to effective leadership and team functioning. First, the aim of my dissertation thesis was to concentrate on factors affecting scientific teams' productivity *positively*. Thus, I wanted to investigate why some scientific teams seem to be more successful than others. In line with this I asked myself: What can both scientific team leaders and team members do better to enhance a scientific team's productivity? If I had investigated factors for failure, I would have asked questions such as: From what should scientific team leaders and team members refrain to improve productivity in their teams? I do not argue that it is less important to investigate factors for failure than success factors. I assume that reducing the occurrence of failure factors such as the prevalence of destructive leadership and dysfunctional communication patterns in teams improves a team's productivity. But we should not stop there. I also assume that fostering success factors such as transformational leadership, the match between personal and workplace characteristics, and the quality of teamwork increases scientific teams' productivity to an even greater extent. Furthermore, I assume that destructive leadership behaviour occurs only in a minor proportion of scientific teams. Literature on destructive leadership and counterproductive work behaviours in teams usually points towards a Poisson distribution of these variables, meaning that only a minority of study participants reported frequent occurrence of such negative behaviours. For example, in a study by Meng, Tan, and Li (2017) on the effects of abusive supervision (AS) on the creativity of postgraduates at several universities, the abusive supervision variable showed a positive skewness coefficient of 2.01 and a positive kurtosis coefficient of 3.98 with a mean coefficient of 1.44 (1 = AS occurs never, 5 = AS occurs very often). This indicates a non-normal distribution and a rare occurrence of abusive supervision in this sample. However, we should be cautious about our conclusions regarding the occurrence of destructive leadership in science, as we cannot rule out the possibility of a self-selection bias in studies (i.e., that only employees who could report positive leadership participated in the survey). Thus, reducing destructive leadership behaviours and dysfunctional communication patterns in scientific teams may improve scientific teams' productivity for a small number of cases. But, if we focus on fostering positive types of leadership behaviours and team interactions, we may reach a greater audience and improve productivity in several scientific teams.

Implications for Research

Even though my thesis answers the question of which factors enhance scientific teams' productivity, a number of open questions remain to be addressed in future research. The final limitation mentioned above, about my strong emphasis on the success factors influencing scientific teams' productivity leads me to the suggestion that future studies should investigate the *factors for failure* of scientific teams' productivity. For example, future studies could assess the occurrence of forms of destructive leadership such as abusive supervision (Tepper, Simon, & Park, 2017) and/or exploitative leadership (Schmid et al., 2017). According to Tepper et al. (2017), abusive supervisors show hostile verbal and nonverbal behaviours such as ridiculing employees, demeaning team members in front of others, and expressing anger for no reason. Exploitative leaders show behaviours such as exerting too much pressure, manipulating team members, and overburdening employees. Meng et al.'s (2017) study on abusive supervision in science is a first step in the right direction, although they did not investigate the effects of abusive supervision through a multilevel framework addressing the effects of abusive supervision on individual- and team-level variables simultaneously. Thus, future studies could investigate the effects of abusive supervision and exploitative leadership on processes such as communication practices in scientific teams, as these forms of destructive leadership may harm team members' intention to share knowledge within the team and collaborate efficiently with team members. Communication may be an especially relevant team-level process, as teams from knowledge-intensive work contexts rely on the exchange of knowledge, skills, and abilities between team members (Hirst & Mann, 2004; Lee et al., 2014; Y. Liu et al., 2011; Wuchty et al., 2007). Against this background, it may be of interest for future research to assess leadership behaviours that foster functional communication practices such as developmental feedback and balance of member contributions and thus prevent dysfunctional communication practices such as knowledge withholding or constant complaining behaviour within scientific teams.

Future studies should focus on investigating the *antecedents of transformational leadership*, as it may be of interest to assess how team leaders can be motivated to show effective forms of leadership such as transformational leadership to foster productivity in their teams (Lanaj, Johnson, & Lee, 2016). So far, studies have investigated the effects of transformational leadership on followers' job performance and well-being. However, research has not yet investigated the *effects of transformational leadership on leader outcomes* such as leaders' well-being. Lanaj et al. (2016) showed that daily transformational leadership behaviours increased the amount of perceived positive affect and decreased the amount of perceived negative affect in leaders through the mechanism of need fulfilment. Thus, transformational leadership has positive effects on leader outcomes as well. However, Lanaj et al. (2016) propose that transformational leadership behaviours may have detrimental effects for leaders as well, as inexperienced leaders may find it challenging to show transformational leadership behaviours on a daily basis. Thus, it could be of interest for future research to investigate factors that foster transformational leadership behaviours in leaders. In line with the person–environment fit theory (Kristof-Brown et al., 2005), which I used as a theoretical explanation for the effects of transformational leadership on follower outcomes in the first study, team leaders need to have some resources to be able to show transformational leadership behaviours and not to suffer in terms of resource depletion (Hobfoll, 1989). The study by Guay (2013) is the first to conclude that the match between personal and workplace characteristics matters to leaders' effectiveness. The results show that demands-abilities fit as another category of person–job fit (i.e., leaders have the ability to effectively deal with work demands) is positively associated with transformational leadership behaviours and leader effectiveness. Thus, if leaders perceive that they have enough resources at work, they show transformational leadership behaviours to a higher degree and thus are rated more positively by their supervisors. However, Guay (2013) did not investigate the effects of other fit dimensions such as person–supervisor fit, person–group fit, and person–organization fit on leaders' behaviours and effectiveness. Thus, future studies could extend these studies by investigating, for example, whether lower levels of the person–environment fit dimensions are associated with a higher degree of destructive leadership behaviours and in turn with lower levels of leaders' effectiveness and well-being.

Implications for Practice

Turning now to the practical implications of my research, I want to highlight the importance of *leadership training programs* in higher education institutions for leaders of scientific teams.

Currently, most leaders in higher education institutions are appointed to their positions mainly on the basis of their research output and their scientific proficiency. As a result, they may lack management expertise and formal leadership training (Cooke & Hilton, 2015). Braun et al.'s (2016) research and my studies stress the importance of effective leadership such as transformational leadership for enhanced productivity in scientific teams. Thus, higher education institutions should offer training and workshops that focus on developing scientific team leaders' effective leadership behaviours when interacting with their employees. These training programs and workshops should rely on Braun et al. (2016) and my (Klaic et al., 2018) research to formulate and convey recommendations for action based on sound research on leadership in higher education institutions. First, leaders of scientific teams should be aware that they need to show transformational leadership behaviours directed towards both individual need satisfaction and satisfaction of team-level needs.

Usually leaders are aware of the fact that they need to lead their individual employees individually, as team members differ in personality, attitudes, values, lifestyles, and thus needs. For example, some team members may be fully absorbed in work when they are enabled to work autonomously, while others may need more direction and structuring to reach their full potential. Thus, scientific team leaders need to *show differentiated transformational leadership behaviours at the individual-level* (Kunze et al., 2016; Nielsen & Daniels, 2012; A.-C. Wang et al., 2012; Wu et al., 2010) to satisfy individual team members' needs. X.-H. Wang and Howell (2010) describe four dimensions of individual-focused transformational leadership behaviours: (a) communicating high expectations, (b) follower development, (c) intellectual stimulation, and (d) personal recognition. Leaders should *communicate high expectations* by encouraging employees to set high goals for themselves and demonstrating high confidence in employees' abilities to meet these performance expectations. Thus, team leaders need to regularly set agreed-upon goals with employees and promote employees' self-efficacy in reaching those goals. Leaders should promote *follower development* by encouraging employees to live up to their potential, suggesting training opportunities for improving employees' work-related abilities, and providing coaching to help employees improve their job performance. Therefore, team leaders should discuss potential training programs or workshop opportunities with employees and support such initiatives in the best possible way (e.g., financially). Leaders should provide *intellectual* stimulation by challenging employees to think about old problems in new ways, having employees look at problems from many different angles, and challenging employees to be innovative in their approach to work assignments. Thus, team leaders should encourage employees to do their work in the most creative and innovative way and foster new, unorthodox ideas and simultaneously discuss with their employees the possibilities and limitations of implementing these ideas. Leaders should provide *personal recognition* by acknowledging employees when they improve the quality of their work. Leaders may do this by offering rewards or gestures of appreciation to celebrate the achievements of their employees and by emphasizing the importance of each employee for team success.

Besides leading team members individually, team leaders need to show leadership behaviours directed towards a team as a whole and thus towards the satisfaction of team-level needs for effective teamwork. It may occur that scientific team leaders believe it is sufficient to assemble a team simply by bringing the most competent and skilled employees together. However, this may result in conflicts within teams and inefficient teamwork (Salas et al., 2015). Thus, team leaders need to show *transformational leadership behaviours at the team-level* to promote efficient teamwork and enhance productivity in scientific teams. X.-H. Wang and Howell (2010) suggest three group-focused transformational leadership dimensions: (a) emphasizing group identity, (b) communicating a group vision, and (c) team-building. Leaders should *emphasize group identity* by saying positive things about the team that make team members feel proud to be members and encouraging team members to place the interests of the team ahead of their own interests. Therefore, team leaders should not only bring employees together to work for a common cause but also emphasize the importance of collaborating with team members to enhance productivity. Further, as mixed-motive situations may pose a threat to effective teamwork, team leaders need to convince team members not only to work for their individual success and focus on their careers but to work for the achievement of team goals and contribute willingly to team success. Leaders should *communicate a group vision* by talking enthusiastically about what needs to be accomplished by the team and expressing confidence that team goals will be achieved. Thus, team leaders need first to set agreed-upon team goals with team members and second promote group potency in being able to achieve those team goals. Leaders should *build teams* by developing a team attitude and spirit among team members and resolving friction among team members in the interest of teamwork. Therefore, team leaders need to foster team-building activities to develop a team spirit and manage conflicts within teams appropriately to enable efficient teamwork.

The results of my studies also stress the importance of recognizing the *mechanisms* behind the relationship between transformational leadership and work-related outcomes. One mechanism involves fostering a close match between personal and environmental characteristics in the work context. In line with the person–environment fit theory (Kristof-

Brown et al., 2005), a high match between personal and environmental characteristics operates as a resilience factor and provides team members with the resources needed to cope effectively with demanding work characteristics. According to my research, scientific team leaders should focus on promoting attitudinal compatibility between supervisors and subordinates (i.e., person–supervisor fit) by showing individual-focused transformational leadership behaviours. As employees perceive transformational leadership behaviours to be desirable, they identify more easily with their leaders (Haslam et al., 2011; Hoffman et al., 2011; X.-H. Wang & Howell, 2012; Zacher & Johnson, 2014). Furthermore, by showing individual-focused transformational leadership behaviours, team leaders foster the correspondence between employee needs and what the job supplies (i.e., needs–supplies fit), because they recognize the importance of taking employees' need satisfaction seriously. Team leaders should also show group-focused transformational leadership behaviours to promote attitudinal compatibility between team members. Group-focused transformational leadership focuses on improving teamwork by promoting team fit, resulting in higher group cohesion, team efficacy, and thus team success (Kristof-Brown et al., 2014).

A second mechanism behind the transformational leadership and work-related outcomes relationship involves enhancing the quality of teamwork by fostering high levels of communication, coordination, balance of member contributions, mutual support, effort, and cohesion. In line with the teamwork quality model (Hoegl & Gemuenden, 2001), these team processes and team-level emergent states contribute to higher teamwork quality. Dong et al.'s (2017) study and my research show that group-focused transformational leadership is a key factor in enabling high teamwork quality. Therefore, team leaders should show group-focused transformational leadership behaviours. In doing so, they encourage team members to communicate frequently, spontaneously, and directly with each other and share information openly. Furthermore, they ensure that every team member is able to contribute his/her task-relevant knowledge and experience in team meetings. By fostering a culture of cooperation instead of competition, team leaders stress the importance of supporting each other within the team. Lastly, by enhancing group cohesion, they ensure team members' willingness to engage in future team projects. However, team leaders need to be aware of the adverse effects of group cohesion on team innovation performance. High cohesion within a team leads to members liking each other and may lead to a fear of criticizing each other and damaging the team spirit. In this sense, it is important that team leaders promote psychological safety in their teams to enable divergent thinking and constructive discussions in the team (Hu et al., 2018).

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